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ANOTHER BROOKLYN BRIDGE TERMINAL PLAN has been suggested by the committee composed of Geo. B. Post, J. C. Breckenridge and Wm. Barclay Parsons, which was appointed to review and report upon the plan of Mr. Neils Poulson, described in our issue of Sept. 11, 1902. The committee condemns Mr. Poulson's plan as impracticable, and submits a plan of its own by which it believes that the maximum relief to trolley passengers can be given without entire reconstruction of the bridge terminal. It is proposed to construct four more loops, at a point about midway between the present loops and the inner end of the station. The report continues as follows:

By moving the galleries, which now connect the mezzanine floor with the several stairways leading to the bridge platforms to the space directly beneath the bridge platform, it is possible to raise them so as to give sufficient headroom for trolley cars to pass beneath them. It will thus not be necessary to interfere with the means of access to the bridge trains above. These new loops can be so situated as to give more intertrack space than is afforded by the present loops. There are 17 lines of trolley cars crossing the bridge, which, under the present arrangement, means more than four lines to each loop. Under the new arrangement there will be but two lines to each loop, except on one loop, where there will be three lines. This will permit cars to stand upon a loop until the next succeeding car arrives, so that passengers will always find a car ready to be entered or one about drawing in. The only work necessary to be done to carry this plan into execution will be to widen the roadways from the end of the present widening to the curve of the roadway at the east end of the station, and to move the galleries, as above described, and to lay the track. The principal delay will be in changing the roadway and getting the special track work for the loops. It is believed, however, that this work can be done in not exceeding 60 days from the time that the order is given. The committee believes that the improvement can be completed at a cost of probably not exceeding $50,000. This plan is therefore one which is reasonable in cost, can be carried into execution with the minimum of delay, and will afford, as stated above, the maximum of facility.

THE CHANGE OF GAGE of the Cincinnati, Georgetown & Portsmouth R. R. was effected on Sunday, Sept. 21. The railway is 42 miles in length, extending from Cincinnati to Georgetown, O., and was originally of 3-ft. gage, but within the present year it has been decided to convert this to standard gage, and also to operate the line by electricity, using the overhead trolley system. Arrangements for the change of gage have been in progress for some time, and the actual work of making the change was accomplished in about five hours. During the past three months, new spikes have been driven outside the rail which was to be moved, being placed at the proper distance by means of a special track gage, made for the purpose. The spikes along the rail were then gradually removed, until by Sept. 20 only about every fourth spike remained. On the morning of Sept. 21, about 350 men were organized in gangs two miles apart. The last passenger train left Cincinnati at 9.15 a. m., Sunday morning, running on the narrow-gage track. This train consisted of two engines and 9 passenger coaches loaded with people, out for an excursion, it being the regular train for Georgetown, O., which is always crowded on Sunday mornings. Immediately after the train passed each gang, the men fell to work pulling the balance of the spikes and throwing the track, being followed by spikers and men putting in switches at various places. This job was all completed in 5 hours. The men were followed from Cincinnati by a standard gage train consisting of a locomotive and five or six coaches to bring in the excursion mentioned above. The widening of the gage of the line was thus successfully carried out without any loss of time of trains. For the above particulars we are indebted to Mr. E. W. White, General Manager of the Cincinnati, Georgetown & Portsmouth Ry.

THE SWEDISH TORPEDO-BOAT DESTROYER "Mode" made an average speed of 32.4 knots in a trial three-hour run on Aug. 28, a higher rate of speed than has been attained by any vessel in the British Navy. The vessel has a displacement of 400 tons and engines designed for 6,500 HP. They are of the four-cylinder triple expansion type with cylinders 20½ ins., 31½ ins. and 34 ins. diameter and 18 ins. stroke. In the contract trial an average steam pressure of 240 lbs. was maintained and the air pressure in the stoke holds was 1½ ins. The engines ran at 421.4 r. p. m. The vessel was built by Yarrow & Co., of London, who have also built ten quite similar boats for the Japanese Navy.

TWO 25-KNOT STEAMERS for Transatlantic service are to be built by the Cunard Steamship Co., as the result of an agreement with the British government. According to the press dispatches, the British government will pay an annual subsidy of $750,000 and the company will build the two vessels mentioned. The government will lend the money for the construction of these vessels, charging interest at the rate of 2¾%, and the company will repay this loan by annual payments extending over 20 years. The subsidy agreement is to remain in force 20 years after the construction of the second steamer. According to the reports the assistance which the government, under this arrangement, renders to the Cunard Steamship Co. is designed for the express purpose of meeting the alteration in conditions of transatlantic traffic caused by the formation of the Morgan shipping combination.

THE DANGERS OF THE ST. LAWRENCE ROUTE for export traffic are summarized by the "New York Times," which quotes statistics from the Liverpool Underwriters' Association, as follows:

From May, 1896, to March, 1902, 20 steamers of 57,203 aggregate gross tonnage were wrecked entering or leaving the harbors of St. John (New Brunswick), Halifax, St. John's (Newfoundland), and Cape Breton. Of these, 13 were total losses, aggregating 38,734 tons, and one of 4,562 tons was still ashore when the table was compiled. One was hauled off Cape Spear badly damaged, and five were able to make port leaking badly and entailing heavy loss. The mortality of steamers engaged in the St. Lawrence trade not included in this summary is said to be on the average of one a month.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between two freight trains on the Bessemer & Lake Erie Ry., near Mercer, Pa., on Sept. 25. Four men of the train crew were killed outright and several injured, one or two perhaps fatally. The wreck was due to conflicting train orders.——It is reported that four men were killed on the Chicago, Burlington & Quincy Ry., on Sept. 25, when a passenger train ran into the rear end of a stock train, near Malden, Ill.——On Sept. 26 an engine on the Northern Pacific Ry. ran away down the side of the mountain near Livingston, Mont., and collided with another engine, killing the engineer and the fireman of the latter.

THE ELLITHORPE SAFETY AIR CUSHION for elevators was put to a very severe test on Sept. 29, 1902, in the Philadelphia City Hall tower. The car with a cargo of eggs and rats fell 365 ft., landing safely. A detailed account will appear in our next issue.

THE UNIVERSAL WATER-METER SYSTEM at Springfield, Ill., was unanimously adopted on Sept. 22 by a vote of the city council. The meters are to be furnished by the city and the system is to be adopted not later than Jan. 1, 1904. The proposed system appears to meet with the thorough approval of Mr. John L. Phillips, Mayor of the city. Mr. C. H. Valentine is superintendent of waterworks.

ELECTRICALLY-DRIVEN CENTRIFUGAL PUMPS to supplement the water supply for irrigation and city purposes at Salt Lake City were installed during the past summer, the fourth one being put in operation on Sept. 8. The pumps have 40-in. suction and discharges, and a rated combined capacity of 400 cu. ft. per sec. The lift is not given. The pumps are driven by four 100-HP. Westinghouse induction motors. The current is supplied by the Salt Lake City Water & Electrical Power Co. at 16,000 volts, and is transformed at the pumping station to 500 volts by means of three 170-KW. transformers. Mr. F. C. Kelsey, of Salt Lake City, was engineer for the power development. Messrs. Gordon & Ingalls, of the Utah Sugar Co., were the contractors. As we understood it, water is pumped from Utah Lake, below the gravity flow level, into the Jordan River, from which a number of canal companies and the city draw water. The city failed to agree with the companies on a joint plan for the work described, but seems to have benefited from it nevertheless. Mr. Angus M. Cannon, of Salt Lake City, is Chairman of the Board of Presidents of the Jordan River Canal Cos., and contributed an illustrated account of the enterprise to the Salt Lake "Desert Evening News" of Sept. 20, 1902.

AN EXAMINATION FOR ASSISTANT ENGINEERS in the Hydrographic Division of the U. S. Geological Survey will be held on Oct. 21, 1902, by the U. S. Civil Service Commission. Persons wishing to compete should send to Washington at once for application forms, which should be executed and filed with the Commission by Oct. 11, 1902. The age limit is 20 years or over. The salary will be $1,000 a year.

PRESSED-STEEL CARS, of 20 tons carrying capacity, are recommended by the Directors of the Prussian State Railways; and they ask that a bill be introduced into the Prussian Parliament providing for the construction of such cars.

MECHANICAL TRACTION IN PARIS is slowly driving out animal traction, says U. S. Consul T. Haynes, of Rouen. In 1901 the census showed that Paris had 96,698 horses that could be utilized in time of war; this year the number has suddenly fallen to 90,796 horses. This reduction is due to mechanical traction Last year the Paris Omnibus Co. used 16,579 horses; it now uses 2,000 less. The Metropolitan Railway, electric and steam trams, motor cars and automobiles account for the missing animals.

MUNICIPAL SMOKE DISPOSAL was suggested by Mr. W. N. Shaw, F. R. S., before the recent Congress of the Sanitary Institute, in England. The plan is not a new one, the author stated, municipal chimneys having been proposed "many years ago" by Mr. Peter Spence, of Manchester. Mr. Shaw recognizes the fact that the practicability of his plan has yet to be proved, but thinks it worthy of investigation, and draws an analogy between municipal smoke prevention and municipal sewage disposal. What might be thoroughly practicable, Mr. Shaw believes, is the combination of adjacent buildings in the matter of chimneys, so that with better facilities for soot collection, better chimney design generally, and higher stacks, the smoke nuisance might be reduced. He also suggests that instead of fining proprietors for producing dense smoke, which has been done for years with comparatively little effect, tax rates be lowered on properties which give no cause for complaint against smoke.

THE COST OF DREDGING for the construction of the Königsberg (Germany) ship channel during the year 1901 was as follows: Two centrifugal pump suction dredges excavated about 367,000 cu. yds. total at a cost per cubic yard of from 5.8 to 9.1 cts., or average 7.0 cts. per cu. yd. Six dipper dredges, excavating a total of 780,000 cu. yds., worked at a cost varying from 5.3 to 9.6 cts., or average 6.8 cts. per cu. yd. One dredge with clam-shell bucket was used on the work, but only for a short time, so that the average cost for it runs up very high, to nearly 25 cts. per cu. yd.

FORESTS FOR PRODUCING RAILWAY TIES are to be established in Cape Colony, South Africa, by the Agricultural Department in conjunction with the Railway Department. The native timbers, while suitable for railway purposes if given a preservative treatment, are not of the best quality, and it has been found that foreign woods of better quality can be grown in various parts of the colony. These woods will include cottonwood, iron-bark, cluster-pine, jarrah, and other species of gum woods. As the trees will be of slow growth, owing to the inferior soil, they are expected to take 30 years in reaching maturity. For about five years there will be an annual expense of about $50,000 to plant, care for and protect the trees. After that time, until the trees mature, the amount realized by the thinning out is expected to cover the expenses. Mr. T. R. Price, General Manager of the Cape Government Railways, refers to the above work in his annual report, and remarks that there is now the satisfaction of knowing that a commencement has been made which will prove of advantage to the country and of economy in railway working. The amount paid for ties during the past four years by the Railway Department aggregates $1,165,000 (of which $595,500 were for ties of native woods); in addition to this, the contractors for railway construction spent about $1,650,000 for ties during the same period.

PROGRESS ON POWER STATION NO. 2 OF THE NIAGARA FALLS POWER COMPANY.

We present herewith a few photographs showing the progress of work on the new power station of the Niagara Falls Power Co., at Niagara Falls, N.. Y. This plant is expected to be ready shortly to begin operation. It has a capacity of 55,000 HP., which brings the total for the two sta-

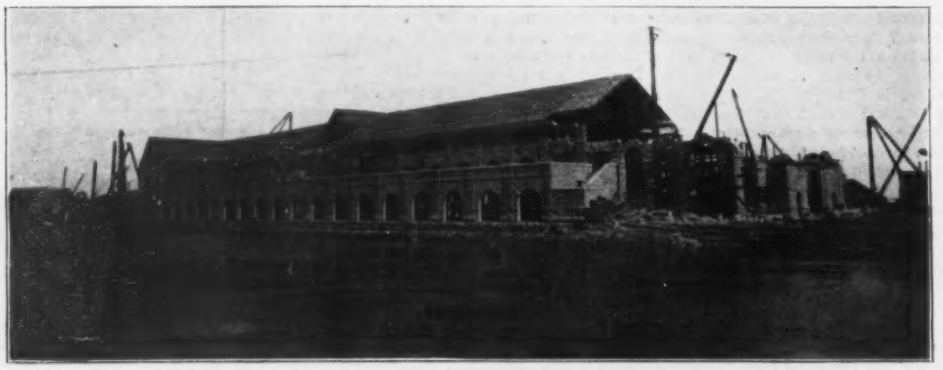

FIG. 1. POWER STATION NO. 2 OF THE NIAGARA FALLS POWER CO., IN PROCESS OF ERECTION.

tions up to 105,000 HP. The station is on the north bank of the headrace canal, near its lower end, with the old power station opposite, on the south bank. The tailwater of the turbines discharges into the tailrace tunnel, which leads to the Niagara River below the falls, just at the location of the 840-ft. steel arch bridge over which the local street railway line crosses the gorge.

Fig. 1 is a general view of the new power house structure, looking about north from the opposite bank of the headrace. It will be seen that the main building has a low side wing toward the canal. This wing constitutes a covered forebay, from which the water flows into the penstocks. In the old power house the screen racks are placed directly in the wall of the canal, exposed to direct contact with floating objects, and to the formation of anchor ice, and they are thus liable to have their inlet areas considerably reduced at times or even to become choked up. That this is not a small matter is evident from the following paragraph, quoted from remarks made by Mr. L. B. Stillwell, in discussion of his paper "The Electric Transmission of Power from Niagara Falls," before the American Institute of Electrical Engineers, Aug. 23, 1901:

> As regards anchor ice, there is a great deal of it encountered at Niagara at certain times. Some of the hydraulic "doctors" have told us that we ought to cease operation under those conditions, but we found that impracticable. Consequently we have done something that none of them has approved, but which seems to be effective—we have simply lifted the racks and let the anchor ice go through the wheels.

In the new power house it is expected that the covered forebay will prevent all trouble from anchor ice. The interior of this forebay is shown in Fig. 2. The wall to the left is the retaining wall of the canal, pierced with arched openings below the water line for admitting water from the canal into the forebay. Through these openings is seen the cofferdam which holds back the water of the canal from the work. The wall to the right is the wall of the power house proper; the screenracks, to be placed across the openings in this wall, protect the entrance to the penstocks. Fig. 3, which is a view just outside the forebay, shows the exterior or canal side of the retaining wall at the right, and the cofferdam at the left. It shows the arched openings leading into the forebay and illustrates the character of the masonry forming the retaining wall.

The view, Fig. 4, shows the interior of the power house, with construction work and installation of the machinery in progress. In the foreground is an opening in the floor through which material can be lowered into the wheel pit. This latter, it may be mentioned, is 464 ft. long, 18 ft. 6 ins. wide and 178 ft. 6 ins. deep. The circular platform just behind this hoisting opening is the foundation for one of the generators, the shaft from the turbine rising through the opening in the center of the platform. The steel framing rising from the floor in the background is the skeleton of the switchboard platform.

In front of this the main oil-switches, operated by relay switches on the switchboard, stand in a long row on the power house floor. The cable subway runs lengthwise of the power house, directly under the switchboard and the oil-switches. The forebay, in Fig. 4, is to the right, and the penstocks lead away from it under the cable subway to the wheel pit. A cross-section drawing of the new power house, which may be of interest here, was shown in Engineering News of July 3, 1902, where will also be found much information about the details of the power station, in a paper by Mr. H. W. Buck, on "The New Generating Plants of the Niagara Falls Power Co."

The superstructure of the new power station is being erected by Mosier & Summers, of Buffalo, N. Y. The wheel pit was constructed by the National Contracting Co., of New York. The turbines were designed by Escher, Wyss & Co., of Zürich, Switzerland, and built by the I. P. Morris Co., of Philadelphia, Pa. The turbine governors, also designed by Escher, Wyss & Co., are built by A. Falkenau, of Philadelphia. The generators, switches, and entire electrical equipment, are furnished by the General Electric Co., of Schenectady, N. Y.

FIG. 2. INTERIOR OF COVERED FOREBAY, DURING CONSTRUCTION.

SAFE SPEEDS FOR FLYWHEELS.*

By Wm. H. Boehm,† M. Am. Soc. M. E.

It is a well understood fact that while an engine or flywheel can be designed to successfully resist the sional stresses due to any load required of the there is no possible way to overcome the centrifug due to speed.

For a given material there is a definite speed at disruption will occur, regardless of the amount of terial used. This is not an uncertain theory but a matical truth easily demonstrated, and is expressed following formula:

$$V = 1.6\sqrt{\frac{S}{W}},$$

in which V is the velocity of the rim of the wheel in per second at which disruption will occur, W the we of a cubic inch of the material used, and S the te strength per square inch of the material.

In words the formula means that if we divide the tensile strength of the material by its weight per cubic inch, extract the square root of the quotient and then multiply this by 1.6, the result will be the rim speed in feet per second at which disruption will occur.

If instead of the ultimate strength of the material we take its safe strength, the result will be the rim speed in feet per second at which the wheel may be run with safety; the supposition so far being, however, that the rim is made solid in one piece, of homogeneous material and free from shrinkage strains.

Applying the formula to determine the safe rim speed for cast-iron wheels made in one piece, we would assume that, if the ultimate strength of small test bars were 20,000 lbs. per sq. in., we could depend upon having 10,000 lbs. in large castings.

Using a factor of safety of 10 on this would give 1,000 lbs. per sq. in. as the safe strength of this material. The weight of a cubic inch of cast iron is approximately 0.26 lb., so that we have for cast-iron wheels:

$$V = 1.6\sqrt{\frac{S}{W}} = 1.6\sqrt{\frac{1,000}{.26}} = 100 \text{ ft.}$$

per second.

So that 100 ft. per second may be regarded as a safe rim speed for cast-iron wheels made in one piece. This corresponds to about 1.15 miles per minute, but as such wheels are likely to contain shrinkage strains it is not considered good practice to run them faster than a mile a minute.

If the wheel is made in halves, or sections, the efficiency of the rim joint must be taken into consideration. For belt wheels with flanged and bolted rim joints located between the arms, the joints average only one-fifth the

*From the "Monthly Bulletin" of the Fidelity & Casualty Co.

†Supt. Flywheel Department, Fidelity & Casualty Co., 97 Cedar St., New York city.

strength of the rim, and no such joint can be designed having a strength greater than one-fourth the strength of the rim. If the rim is thick enough to allow the joint to be reinforced by steel links shrunk on, as in heavy balance wheels, one-third the strength of the rim may be secured in the joint; but this construction cannot be applied to belt wheels having thin rims.

Applying the formula to wheels made of cast steel, having an ultimate strength of 60,000 lbs. per sq. in., or a safe strength of 6,000 lbs. per sq. in., and weighing 0.28 lb. per cu. in., we have

$$V = 1.6\sqrt{\frac{8}{W}} = 1.6\sqrt{\frac{6{,}000}{.28}} = 233 \text{ ft.}$$

per second.

So that a cast-steel wheel made in one piece and free from shrinkage strains could be run with perfect safety at a rim speed of 233 ft. per second, corresponding to 2.66 miles per minute.

It will perhaps surprise some of our readers to learn that wheels made of wood may be run at a higher speed than those made of cast iron. Wood, however, is one of the very best materials that can be used for flywheel construction, and many large wheels have been constructed of this material and are giving satisfactory results.

Applying the formula to hard maple having a tensile strength of 10,500 lbs. per sq. in., and weighing .0283 lb. per cu. in., we have, using a factor of safety of 20, and remembering that the strength is reduced one-half because the rim is built up of segments,

$$V = 1.6\sqrt{\frac{8}{W}} = 1.6\sqrt{\frac{262.5}{.0283}} = 154 \text{ ft.}$$

per second.

So that a well-made maple wheel may be run with perfect safety at a rim speed of 154 ft. per second, which corresponds to 1.75 miles per minute. Or comparing two wheels of the same diameter, one of cast iron, the other of maple, the number of revolutions per minute for the maple wheel may be 54% greater than for the cast-iron wheel. One hundred and fifty-four feet per second would not, however, be a safe rim speed for the wood wheel if made in halves or sections, on account of the weakness of rim joints.

Of late years wheels for large electric plants have been built up of steel plates riveted together, and wheels for special work or unusually high speed have been specially designed. It is questionable, however, whether the complicated built-up steel construction is profitable for wheels of standard steam engines as commercially built. When an engine runs fast enough to burst a well-made cast-iron wheel it is doubtful whether anything could save it. The small amount of time required for the additional acceleration necessary to burst a steel wheel at that stage would be little, and when the crash did come, it would be all the more disastrous.

From the above formulas it will be seen that the stress in the rim of a wheel increases with the square of the speed, or, to put it another way, the factor of safety on speed is always the square root of the factor of safety on strength.

If the speed be tripled, for example, the stress in the rim becomes nine times as great as before; that is, with a factor of safety of nine on strength, there is a factor of safety of only three on speed. It will be understood from this that the stress increases enormously for even a slight increase in speed.

FIG. 3. INLET OPENINGS THROUGH RETAINING WALL OF HEAD-RACE CANAL.

Let us consider the usual cast-iron, sectional, belt-wheel having flanged and bolted rim joints located between the arms. As pointed out above, such joints average a strength of only one-fifth the strength of the rim, and no joint of this kind can be designed that will have a strength greater than one-fourth the strength of the rim. If this wheel had at normal speed a factor of safety of 12 in the rim, then with joints of maximum strength the factor of safety in the joint would be only 3 on strength or 1.73 on speed. That is, an increase in speed of 73% would burst the wheel.

The wide gulf in this case between the apparent factor of safety of 12 on strength and the real factor of safety of 1.73 on speed is appalling. This is, however, only another warning that things are not always as they seem.

As a matter of fact, few wheels have a margin of safety of 73% on speed. In the accident at the Amoskeag Mills, in which a 30-ft. wheel wrecked the building, killed two girls and badly injured the assistant engineer, the evidence proved that an increase in speed of only 20% caused the disaster. Many wheels in use to-day are running on a narrower margin than this.

It will now be understood why racing is so frequent a cause of flywheel accidents. Some slight accident to the governor or valve gear of the engine occurs, and away goes the wheel, causing a costly if not fatal wreck. The stress in the rim increases so rapidly with increase of speed that sound wheels amply safe at normal speed, go to pieces without warning, and apparently without cause.

THE THIRD-RAIL ELECTRIC SYSTEM ON THE NEW YORK, NEW HAVEN & HARTFORD R. R.

In the article on "The Third-Rail and Trolley-wire Systems for Interurban Electric Railways," in our issue of Aug. 14, reference was made to the use of the third-rail system on the electrically-operated lines of the New York, New Haven & Hartford R. R., and we have recently received information as to the practical working of this system from Mr. N. H. Heft, Chief of the Electrical Department of that road.

The company was led to experiment with the third-rail system through a desire to obtain the simplest and least expensive method of transmitting power. The cost of installing the third-rail system was found to be very much less than the overhead system, and the comparative cost of maintaining the third-rail and overhead systems has been found to be very much in favor of the former. Practically the only item of expense in connection with the maintenance of the third-rail system is the renewal of underground cables at crossings. From experience gained with the present installation, Mr. Heft hopes to be able to place cables under the crossings in such a manner that there will be practically no deterioration. When this has been accomplished, the only expense will be an occasional tightening of the bolts at the joints of the rails, which will amount to very little.

The third-rail system is in use between Hartford and Bristol (18 miles), and between Berlin and New Britain (3 miles) in Connecticut; and between Braintree and Cohasset, in Massachusetts (11.5 miles). The average speed maintained in operation under the regular schedule is about 35 miles per hour. The right of way is fenced, and at grade crossings the ordinary surface cattle-

FIG. 4. VIEW OF INTERIOR OF POWER HOUSE, DURING CONSTRUCTION.

guards are in use. The voltage carried by the third rail is from 550 to 650 volts.

One of the great obstacles that has been encountered in introducing this system, which presents so many advantages, is the fear of liability of persons being killed or injured by coming in contact with the third rail, and also the fear of trouble caused by persons tampering with the rail. The experience on the Albany & Hudson Ry. (noted in the article above referred to), and on the New York, New Haven & Hartford R. R., appears to indicate that the danger of the third rail has been exaggerated, and that the objections to it on this score have not been well-founded. The right of way should, of course, be fenced in, and provided with cattle-guards at road crossings; then if people persist in trespassing they must be held responsible if they receive injury. As to the matter of tampering with the rail and short circuiting the current, the strength of the current will usually soon burn out and destroy any small connection such as a wire, and if the railway companies take prompt action and have the offenders arrested, the publicity and punishment will soon have a deterrent effect upon mischievous persons. This course of action has been taken by the Aurora, Elgin & Chicago Ry., whose line was recently opened, and several boys have already got into trouble. Probably in a few months the railway will be so familiar that it will not suggest itself as an outlet for mischievous tendencies, and will not be tampered with any more than the steam railways. In regard to the experience in these directions on the New York, New Haven & Hartford R. R., we give Mr. Heft's statement in his own words, as follows:

We have had very few accidents due to the location of the current conductor. A few persons have come in contact with the rail, and have received slight burns. Two persons have been found dead on the track, but in both cases there has been reasonable doubt as to the cause of death. One (a man) was subject to epileptic fits, and was known to have been under the influence of liquor the night before he was found. The other (a boy) was also known to be subject to fits, and it is thought he may have been taken with one while walking along the track, and that, while in an unconscious condition, he remained in contact with the third and service rails a sufficient length of time to be killed. With these exceptions, we have had practically no serious accidents on account of the location of the third rail.

A few dogs and one horse have been killed by coming in contact with the third rail. The horse was running away and took to our roadway at a grade crossing. We have also had several dogs so seriously shocked while loitering about our tracks, that they have thereafter religiously avoided the vicinity of the railway in general, and the third-rail track in particular.

We have experienced trouble on our Hartford & Bristol line from boys and mischievous persons causing short circuits by throwing metallic substances across the third and service rails. We have succeeded in bringing one or two such persons into court, and the result has been that we now have practically no trouble from this source.

METHODS EMPLOYED IN THE CONSTRUCTION AND MAINTENANCE OF THE MASSACHUSETTS PIPE LINE GAS CO.'S MAINS IN BOSTON AND VICINITY.

By W. W. Cummings,* M. Am. Soc. C. E.

It often happens that an engineer is confronted by the problem of doing a certain amount of work with a limited sum of money, and the only way he can keep the cost within the required limits is to so systematize the reports that he can see at any time what the expenses are for the different items and trim them accordingly. In the ordinary methods of book-keeping, unless a considerable force is kept on the accounts, the knowledge of excessive cost is obtained too late to be of much benefit to the work in hand.

In the construction of the Massachusetts Pipe Line Gas Co.'s mains, the writer had occasion to regret that no previously tried system was available, and after considerable study devised the following methods, which may possibly be used as a base in similar cases.

When the Massachusetts Pipe Line Gas Co. commenced to lay its mains, it was given a limit of cost of $9 per lin. ft., complete, which was to include all repairs and changes to other pipes, conduits, sewers and paving. Much of the route was through districts congested by travel above and obstructed by existing structures below.

*Consulting and Constructing Engineer, 53 State St., Boston, Mass.

1901. Three contractors were employed on work.

Rates of labor were as follows:

Foreman	$0.45 per hour.
Subforeman	.35 " "
Subforeman	.30 " "
Bracers	.25 " "
Calkers	.25 " "
Pavers	4.00 per day (9 hrs.)
Tenders	2.00 " "
Laborers: Derrickmen, bottommen, bracers' tenders, pavers' tenders, pipe layers, leadmen	.20 per hour.
Laborers	.18 " "
Laborers	.17½ " "
Laborers	.17 " "
Laborers	.16 " "
Laborers	.15 " "
Blacksmith	.20 " "
Blacksmith's helper	.15 " "
Lampman	.15 " "
Toolman	.20 " "
Watchman	.15 " "
Carpenter	.25 " "

The office force consisted of:

1	bookkeeper	$60.00 per month.
1	time-keeper for each contractor.	80.00 " "
1	time-checker for each gang....	12.00 " week.
1	engineer for each contractor ...	75.00 per month.
1	rodman for each contractor	50.00 " "
1	yardman for each yard	60.00 " "

The time-keepers and checkers were men selected for their reliability and diligence and were paid good wages. The checkers patrolled the line at irregular intervals, at least every two hours, and returned a slip to the time-keeper, showing the men and teams at work each trip with the date and time on each slip. The entire route was mapped and separated into divisions and sections. The different cities constituted the divisions, and were let to different contractors, while the sections were divided according to the anticipated character of the work. That which

MASSACHUSETTS PIPE LINE GAS CO.

DAILY PIPE REPORT.

Received into

Contractor ..... Park St Yard. Date July 7th. 1899

CARS Number	CARS Initial	PIPE Size	PIPE Number	WEIGHTS AND Numbers						Wagon DESTINATION	REMARKS
			2376							12,621,957	
2769	P R R	36"	6	2590 / 5245	2591 / 5327	2592 / 5183	2593 / 5164	2594 / 5225	2595 / 5237	31,381	M. Ward.
2820	Penna Co.	36"	6	2596 / 5212	2597 / 5180	2598 / 5020	2599 / 5200	2600 / 5030	2601 / 5118	30520	M. Ward.

MASSACHUSETTS PIPE LINE GAS CO.

DAILY PIPE REPORT.

Contractor Mass. P. L. Gas Co. Shipped from Park St Yard. Date July 7th. 1899

CARS Number	CARS Initial	PIPE Size	PIPE Number	WEIGHTS AND TEAMSTERS				DESTINATION	REMARKS
				Jackson	Wright.				
		36"	2597	5180				Cor. Ist & Z.	The Neat.
		36"	2601	5128				Fremont Coliseum	

EXHIBIT I. YARD REPORTS; SHOWING MATERIAL RECEIVED AND DELIVERED.
(On paper 12 ins. wide and 10 ins. high.)

The work consisted of laying: 2½ miles of 42-in. pipe, laid in a double line; 3½ of 36-in., double; 1½ of 36 and 30-in., side by side; 7 of 36-in., single; 1 of 24-in. pipe, single. Also three river crossings, described in Engineering News of Oct. 3,

FIG. 2. SLINGING A 36-IN. BRICK SEWER.

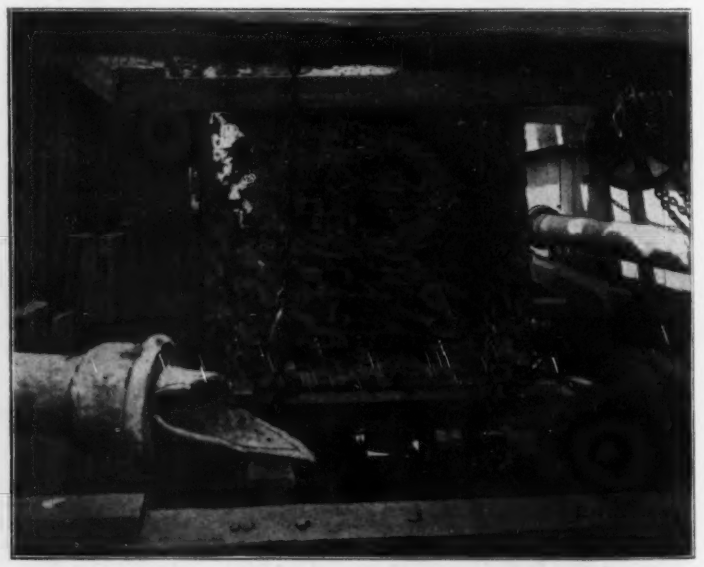

FIG. 3. SLINGING A BRICK CATCH-BASIN.

SUSPENDING BRICK SEWER AND MANHOLE, CAMBRIDGE, MASS., WHILE LAYING TWO 36-IN. MAINS; MASSACHUSETTS PIPE LINE GAS CO.

MASS. PIPE LINE GAS CO.

Foreman Colleran 's Report No. 21

Work Date July 7 1899

Location Div. H. Sec 2

	No.	Previous	Hrs.	Rates	Amt.	Total
Foremen	1	90 87	10	45	4.50	95.37
"	1	35 60	10	.35	3.50	39.15
"	1	36.40	10	.30	3.00	39.40
Laborers	50	3510.90	10	17½	88.50	
"	27		8	17½	37.50	
"	34		10	15	51.00	
"	6		8	15	7.20	369.60
Firemen					184.50	
Carpenters		71.42				76.42
Blacksmiths		41.60	9	.30	1.80	43.40
Caulkers		36.00				36.00
Pavers		9.25				9.25
" Tenders		6.75				6.70

Front.

	No.	Previous	Hrs.	Rate	Amt.	Total
Derricks	1	16.00	10	.05	.50	12.50
Tool boxes		44.00			2.00	46.00
Furnaces	2					
Blacksmiths' kit	1	15.20			.75	15.95
Pumps diaphragm	5					
" votary						
" steam						
Pulsometers						
"						
Lanterns	117					

Reverse Side.

Exhibit II. Time-Keeper's Report.

(On both sides of manila paper, 3⅝ ins. wide and 8 ins. high. The forms extend to include all classes of labor, including teams, and all sorts of tools used on the rock. Provision is made for totals.)

required piling being one section, that containing rock cut another, where the line crossed private land, passed under the various kinds of street surfacing, was near a railway, etc., each a distinct section. The idea being that the cost of these different classes of work would show in the reports of the sections without further separation.

Five receiving yards were established along the line, where all pipe and material were delivered. Here the pipes were inspected, and a number was marked on the inside of each one with white lead.

turn a daily report for each gang, made in duplicate, showing the number of men of different classes employed, the rates of wages, the daily wages and the total wages to date, on each section on one side, while a list of the tools in use with the daily and total rentals, if any, were shown on the reverse side. He also noted on this card the numbers of the pipes received and their condition, and the other material received. This report guarded against loss of tools and the material in transit to the work.

Of course the total daily pay-roll of the card checked that of the time books. Exhibit II. describes this report.

The Division Engineer was required to return daily reports for each section (Exhibit III.) made in duplicate, showing the excavation, back-fill, paving, repairs made, material used, the numbers of the pipes laid in their order, with remarks covering anything that would affect the cost This guarded against the loss of material while on the ground. Both the engineer's and time-keeper's reports were cards of convenient size for the coat pocket, and stiff enough to avoid crumpling, bound in book form, perforated, and having a thin sheet of parchment for the duplicate.

At the office the book-keeper entered the pipe as ordered and the data from the cards on a page (Exhibit IV.), which gives the pipes ordered, received, to come, delivered, to each section, laid in each section, on hand, and the length as obtained by average laying length (used as a check).

Nearly all the pipe and specials were ordered from the McNeal Pipe & Foundry Co., and the R. D. Wood Co., and the columns headed "McN." and "W." refer to the castings from those dealers

The book-keeper also had a ledger account in detail (Exhibit V.) which he took from the reports showing the material received, used, and transported from each section. This account served to simplify the entries to be made on the page ruled, as in Exhibit VI., and further guard against loss.

In practice the daily report cards from the yards, the time-keepers and the engineers, were mailed the evening of the day recorded and reached the office at 8 a. m. The book-keeper made his entries on the pages, described by Exhibits V. and VI., and transferred his totals to the page, described by Exhibit VII., which made the information in detail for the day recorded available by noon of the following day.

The results were combined in a similar manner for each division, as shown by Exhibit VI., and again for the entire work. These totals were made up each week unless required oftener by the bad showing.

MASSACHUSETTS PIPE LINE GAS COMPANY.

DIV. H SEC. 2 Brookline DATE July 7 Foreman Colleran

									PREVIOUS	DAILY	TOTAL
Rock Excavation	Long	Wide	Deep	Men	Rate	Powder	Loc.				
Trench Opened	100	5	5½	Station 41370		to	Station 41370		204'4½	100'	2197
Back Filled	90	5	6	40155			49155		1350	109	1459
Concrete									50		50
Paving			Sq. yd.						4200		4200
Puddling	90	5	6½ Deep	40155			49155		1333	68	1401
Pipe Laid 3 lines		6	Lengths			Numbers		Insp.	205'6½	100.58	2136.75
Joints Run	12			Caulked	12		Lead Used	12.50	17' 50½	1209	1379
Masonry		Brick		Cement		Mos		Rate	74.64		174.80
Piles		Long.	Caps	Men	Rate						
Test		Pipe	Time	Gauge	Thr.	Loc.					
Sewer Con. 1-6"		Bends	Tees	Branches		Entered	Dropped	20 Loc.	from # 100 Hanson St		
" "											
" "											
" "											
Water Services	Coop.						167'5"		from # 95-97-99 Hanson St		
26 "		9-15				22"			" # 93-95 " "		
Water Mains	Ft.	Pipe	Offsets	Ells							

Front.

Pipe Numbers 2357 — 5212
2354 — 5180
2359 — 5020
2346 — 5200
2355 — 5030
2360 — 5178
1/16 { 1800 — 2652 / 1500 — 2712
1/8 1200 — 2840

Mc Spruce Plank used 1100 ft BM
" " Rough 200 " " "

Received from Wharf yard
Tighe — 5500 2" spruce
Mut'n Explos 6 duff pipes
Donovan — 3500-2" Spruce

Rec'd from Park St Yard
12—36" pipe 2597 — 5180
" 2601 — 5178
2599 — 5200
2598 — 5020
2590 — 5245
2591 — 5327
837 — 5226
827 — 5200
828 — 5224
826 — 5228
824 — 5190
823 — 5106
62324 #

Reverse Side.

EXHIBIT III. ENGINEER'S REPORT ON WORK DONE, MATERIALS USED, AND FACTORS INFLUENCING COST.

(On manila paper 7⅝ ins. wide and 3¾ ins. high, with pencil notes on reverse side.)

A report (Exhibit I.) was made in triplicate, containing this data, together with an account of everything shipped from the yard, the division, section and foreman shipped to and the teamster hauling the load. One copy of this report was sent to the office daily, another was forwarded to the auditor and the third remained in the book as a record. The time-keeper was required to re-

The book-keeper also compiled a record of the pipe from the yard keepers' and engineers' reports on a page ruled as shown in Exhibit VII., by which any lost pipe could be traced and damage assessed.

A "Division of Labor" sheet, showing the cost of the different items, was sent to the auditor each week. He also received the bills, and kept independent accounts. A daily report, described by Exhibit VIII., was sent to the president and chief engineer.

The division engineers also kept field books, giving the grade and laying length of each pipe, and the pipe numbers, in the order of their laying. The intersections of cross street lines and important underground structures were noted by station, the locations of each special were tied in to permanent points and the lateral distances from street lines and other pipes, sewers, conduits, etc., were noted.

When repair work was done by city men, a report of the labor, materials and prices, was added to the engineer's card, together with the location of the repair. This was credited to the city on a page for that purpose, and when the bill was presented it was "o k'd" from that page.

The highest cost per lineal foot of pipe was $11.61, including all repairs, pipe, etc. This was one 36-in. pipe in rock cut, with a 12-in. gas main on one side and a water pipe and sewer on the other.

The lowest total cost per lineal foot of pipe, for two 36-in. pipes side by side, was $8.16; do., for one 24-in. pipe, $4.29.

The average total cost per lineal foot of pipe was $8.36.

The average total cost of pipe per lineal foot was $4.20, including specials.

The cost of pipe per ton was $17.50 f. o. b Philadelphia. The cost of specials was 2¼ cts. per lb.

The average cost of excavation (including sheeting) was $1.86 per lin. ft.; for laying (including lead, etc.), 62 cts.; back-filling (including

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surfacing), 72 cts.; handling (includes unloading cars and piling in yard) was 76 cts. per lin. ft.

This does not include engineering other than as above mentioned. The location sheets were as shown by Fig. 1 (Exhibit IX.), giving the station of the side streets and specials, with the lateral distance from street lines and other pipes, conduits, etc., wherever obtainable. Each special

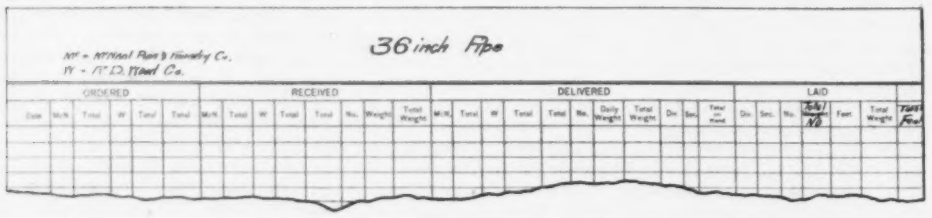


EXHIBIT IV. PIPE SHEET, SHOWING PIPE ORDERED, RECEIVED, DELIVERED AND LAID, WITH APPROXIMATE LENGTH FIGURED FROM LAYING LENGTHS.
(On sheets 12⅝ ins. wide and 17⅞ ins. high, duplicated on reverse.)

is tied in from permanent points, so that any joint can be found by locating a special and measuring the distance given in the field books, while keeping on the offset from the street lines.

A further compilation was started, as outlined in Exhibit X., which is modeled on the form used at Halifax, N. S. This gives at a glance all the information connected with the line, but requires a great deal of time. In the case of the Massachusetts Pipe Line Gas Co., it was reserved for winter work.

In laying the pipe, 2-in. plank cut 4 ft. long was laid on undisturbed earth, lengthwise of the trench, and a 4 × 6-in. cross-piece was placed on these. This was done in at least two places, the material. All of these places have remained in position.

Previously tested joints, after being exposed to the sun for a few hours, showed leaks due to unequal expansion on re-testing. This was overcome by keeping wet bags of sand on the joints until they could be tested and covered. Backfilling with hot, sandy material also caused leaks.

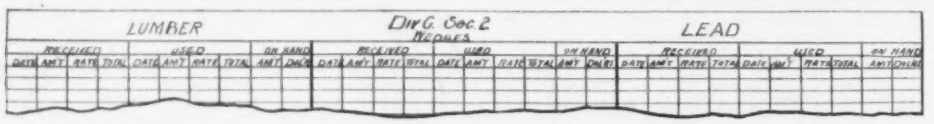


EXHIBIT V. LEDGER SHEETS, TO SIMPLIFY ENTRIES ON EXHIBIT VI., AND TO CHECK MATERIAL USED ON EACH SECTION.
(On sheets 16 ins. wide and 10½ ins. high.)

In case of repairs and leaks, slips (Exhibit XI.), modeled after those of the Boston Gas Light Company, W. R. Addicks, Engineer, are filled out and filed in a card index under the heading of street names.

Each drip is numbered from the Everett works and a record (Exhibit XII.) is kept of the depth of drippage and the gallons pumped each visit. The drip wagon contains about 200 gallons, and has a float whose spindle is marked every 25 gallons. By tabulating for each drip the measurements in inches and the number of gallons pumped, it was easily seen about how much drippage there was for each inch, even though the water extended into the pipe (which is often the case in some drips where the pipes have a slight fall), so that a measurement now gives the approximate gallons to be pumped. Each valve is lettered from the works.

These drips and valves are located in the usual currents reaching a potential of five ohms. A bar of steel lowered into some of the drips is drawn violently to the side by magnetic action. It is needless to say that electrolysis may be expected in such districts. Owing to some of the joints on the line being of cement, connecting the line to the rail in these places would be particularly bad policy. The placing of a large-sized pipe in a street already well filled with other rights of way is no simple matter, especially so when the pipe is a gas main where drippage must be provided and leaks re-calked and two parallel 42-in. pipes in the same trench simply increase the difficulties. Figs. 2 and 3 show how a brick sewer and catch-basin were suspended in Cambridge.

MASSACHUSETTS PIPE LINE GAS COMPANY.
July 7th, 1899.

FAIR:

Mr. Cummings in office 8:10. Tunnel, Boston, Roxbury, Brookline, Cambridge, office 5:45. Sullivan in office 8:10, 95 Milk St., office till 5. Tabor in office and works all day. Silsbee and Jeeves in office all day. Murry and assistants in Roxbury, Brookline and Jamaica Plain. Hayden and assistant in Cambridge giving grades.

Div. D. Secs. 1 and 2, Cambridge.

Laborers	233	Engineers	2
Carpenters	3	Pumpmen	20
Blacksmiths	1		
Night watchmen	12	Total	270
Day watchmen	10		
Derricks	1	Supply wagon	1
Furnaces	2	Single carts	1
Blacksmith kits	1	Double carts	40
Pumps	5		

302 lanterns out. Sec. 1, ¾-yd. concrete, 140 sq. yds. paving, 60 ft. edgestones, 114 yds. brick laid, 45 ft. pipe laid, 8 joints calked, 8 pigs lead used, 1 sewer connection made—25 ft. 5-in. pipe, 1 6-in. ¼ bend used.

Sec. 2. 175 ft. trench opened, 75 ft. back filled and puddled, 268.84 ft. pipe laid 17 joints calked, 15 pigs lead used, 15 piles driven, 8 caps used.

Exhibit VIII. Portion of Daily Report to President and Chief Engineer.
(On letter paper; other portions similarly covered.)

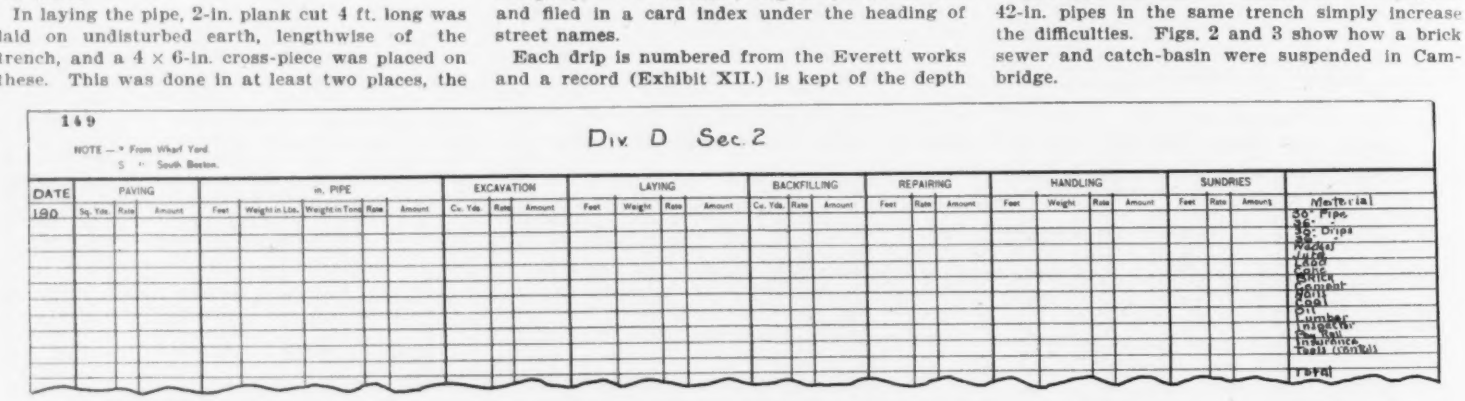


EXHIBIT VI. SHOWING DAILY COSTS AND RATES.
(On sheets 18 ins. wide and 12¼ ins. high, duplicated on reverse. Totals to date of balancing are given for each section and division, and for the entire work.)

area in contact with the earth being calculated to support the pipe full of water, the earth above it and half a 15-ton steam roller. The blocking for the drips was calculated similarly. The pipe has settled in but few cases, and in each of these it has been found that the above requirements had been slighted.

Before being back-filled the joints were tested by 48 ins. of air pressure. The minimum fall allowed was ½-in. to the length of 12-ft. pipe, and the extreme distance of open joints on the inside was ¾-in. at the base of the bead. The pipes were dropped a foot or so to settle the blocking, and in no case was earth allowed to be filled in under the blocking in laying.

When the ground was soft, piles were used, driven by machine or by hand, according to the length required, and in one case where piles could not be used, gravel was rammed into the soft way by stenciling rectangular co-ordinates on permanent nearby points. All drips are sounded and the valves started once each month.

In most of the districts the mains are negative with regard to the electric car rails, but in some places they are subject to very heavy departing

It would be unfair to close without tribute to the resourcefulness and push of Mr. L. J. Hirt, who was the chief engineer during construction.

A DOZEN YEARS' EXPERIENCE IN SEWAGE PURIFICATION AT SANTA ROSA, CAL.

After a dozen years or so of experience with various methods of sewage disposal, the city of Santa Rosa, Cal., is now trying a combination of septic tanks, a settling tank, and upward filtration, in the order named.

The population of Santa Rosa was 3,616 in 1880, 5,229 in 1890, and 6,673 in 1900. The present population is estimated at 7,500. A public water supply was introduced in 1873 by the Santa Rosa Water Co. The exact date when the first sewers were put in use cannot be given, but on April 9, 1891, Mr. Newton V. V. Smyth, then City Engi-

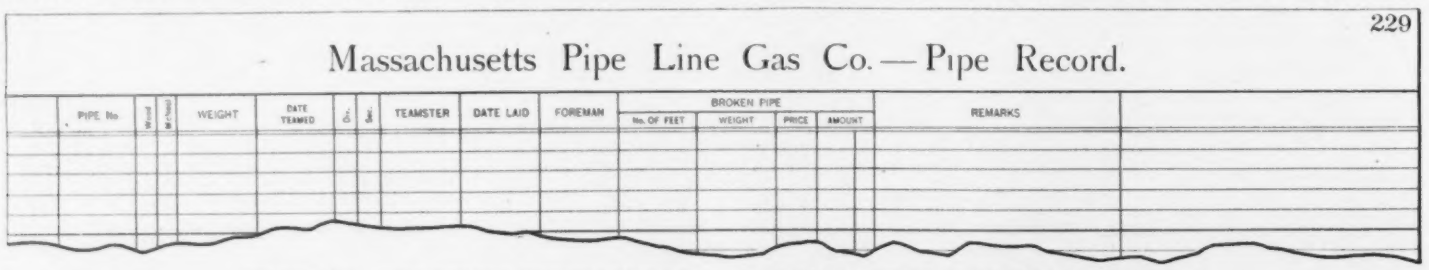


EXHIBIT VII. PIPE RECORD FOR TRACING LOST AND BROKEN PIPE AND ASSESSING DAMAGES.
(On sheets 18½ ins. wide and 14½ ins. high, with duplicate on reverse.)

neer, wrote us stating that "a number of years ago a sanitary engineer was employed to mark out roughly a plan for sewering the thickly settled portion of the town."

The engineer, who appears to have had little choice in the matter, submitted a "chart" showing some elevations and providing for an outlet into Santa Rosa Creek, at the edge of the town. Two or three streets, Mr. Smyth states, were sewered on the separate plan, with discharge into the creek. A lawsuit over pollution of the creek caused the city to buy between 18 and 19 acres of land about two miles below the city and build an outlet sewer thereto. Mr. Smyth stated, in April, 1891, that the city gave the use of the land and sewage to private parties for gardening purposes in return for the care of the sewage. Some of the solid matter in the sewage was diverted from the farm into a pit by means of a gate at a rise in the outlet, near its end. The sewage not used for irrigation was discharged onto low ground near the creek, which ground was flushed at high water. Owing to a lack of records, Mr. Smyth could not give the extent of sewers and the number of connections at the time of his report.

From the foregoing it would appear that the city bought the land prior to 1890, and that sewage farming began in 1890 or earlier; but the disposal of the sewage, as might be expected under the circumstances, was not satisfactory, and in or about 1894 farmers on the creek below the sewer farm brought a suit against the city which resulted in a decision, in the superior court, to the effect that the water and air for several miles below the farm were being polluted, causing fever. This statement was made in a letter from a trusted correspondent of this journal, dated April 18, 1902. Our correspondent also said that "about 7 or 8 years ago" the sewage was treated by chemical precipitation, and then applied to the sewage farm. The latter did not pay and filter beds were substituted for the farm. These gave a clear effluent, which was discharged into the creek without causing complaint. All went well until February, 1902, when high water "wrecked the plant," which (April 18, 1902) "has been partly restored, but meanwhile experiments are being made with a septic tank."

Information regarding the more recent changes in sewage disposal has been received, dated June 26 and Aug. 19, 1902, from Mr. J. W. Keegan, councilman and chairman of the sewer committee.

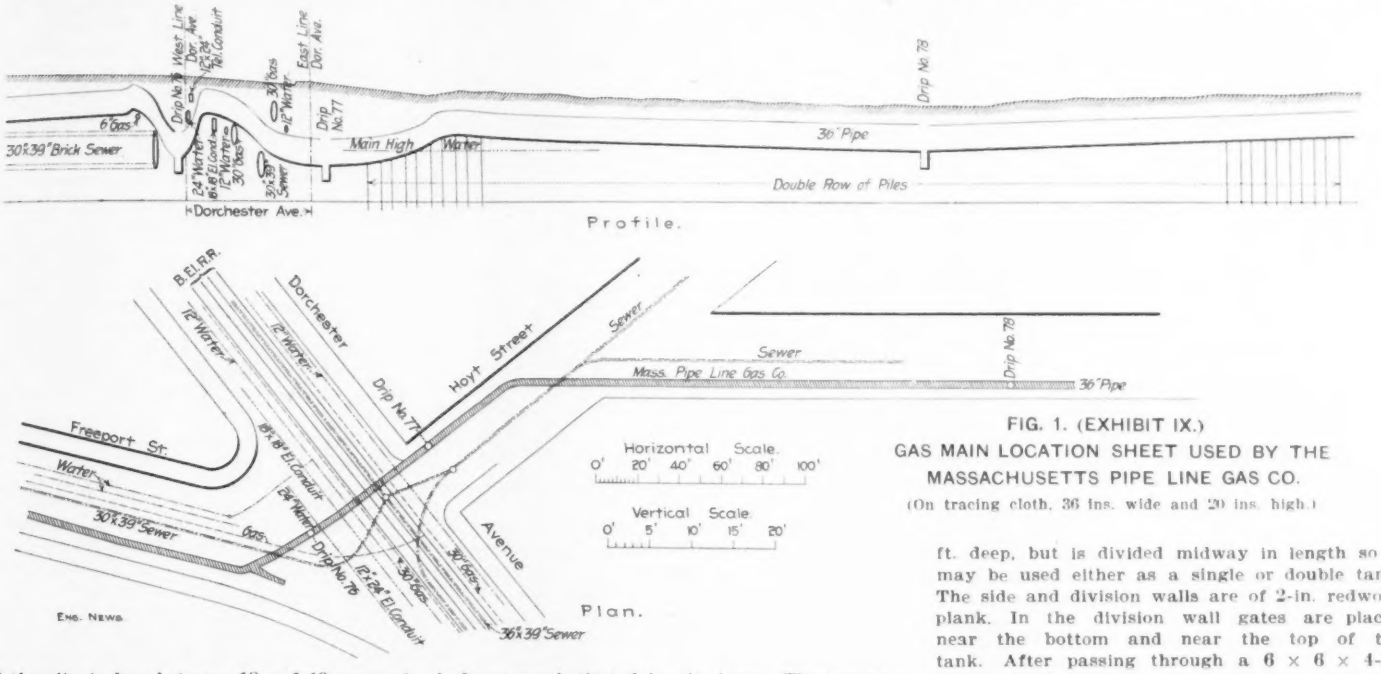


FIG. 1. (EXHIBIT IX.)
GAS MAIN LOCATION SHEET USED BY THE MASSACHUSETTS PIPE LINE GAS CO.
(On tracing cloth, 36 ins. wide and 20 ins. high.)

The new septic tank, put in use in the month of July, 1902, is 18 ft. wide, 280 ft. long and 8 ft. deep, but is divided midway in length so it may be used either as a single or double tank. The side and division walls are of 2-in. redwood plank. In the division wall gates are placed near the bottom and near the top of the tank. After passing through a 6 × 6 × 4-ft. grit chamber, the sewage enters the new septic tank 3 ft. below high water. There are two current breakers in the first section, and one in the second section, so located as to divide each section about equally in length. At the outlet end, or the farther end of the second division, a scum board extends nearly to the bottom of the tank. The whole tank is covered with a flat roof of redwood flooring, protected with coal tar, above which is earth.

The effluent from the septic tank is conveyed to

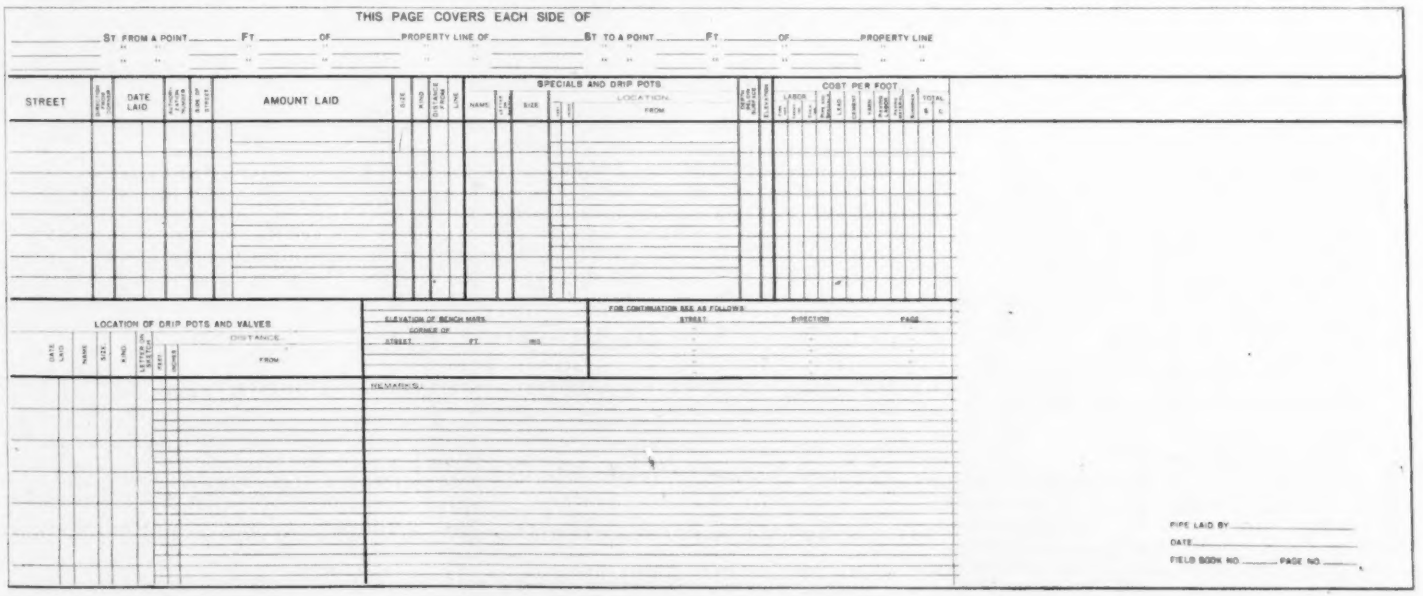


EXHIBIT X. PART OF STREET RECORD SHEET.
(On sheets 38 ins. wide and 10⅝ ins. high. The part omitted is blank, except for the continuation of the profile lines.)

The first septic tank at Santa Rosa, as nearly as we can judge from the statements made by Mr. Keegan, and by the correspondent already named, was put in operation as a septic tank in March, 1902, just after the storm and accompanying damage already mentioned. It was a simple earth pit, or ditch, apparently built in April, 1900, its primary object being to receive sludge from the old a covered settling tank, 22 ft. wide, 60 ft. long, and 5 ft. deep, with a division wall running from end to end. Here most of the inorganic floating particles in the effluent are deposited, to the great relief, Mr. Keegan says, of the filter beds. This tank is covered by a building with a pitched roof provided with a ventilator. The tank was roofed because, Mr. Keegan states, "most of the

bad odors come from the (septic tank) effluent when first exposed to the air; also to allow bacterial action to continue undisturbed."

A pump, driven by a 3-HP. gasoline engine, is mounted over a sump at the outlet end of the settling tank, for use in pumping out any sludge that may accumulate. This sludge, it is now proposed, will be delivered into the old septic tank, or sludge pit.

When sewage irrigation is practiced, which is but rarely now, the effluent from the settling tank is sent directly to the irrigation area. At all other times it is filtered before it is discharged into the creek. There are two sets of beds. The first set is underground, and the sewage is admitted at the bottom, through perforated pipes, covered to a depth of 6 ft. with large cobble stones, above which are old brick and furnace clinkers. There are (August, 1902) eight filter beds, each 8 ft. wide, 60 ft. long and 6 ft. deep. Each bed receives sewage for two days (but Mr. Keegan thinks "one day is enough").

From these underground filters the sewage passes to four large, open sand beds, having an area of about one-fourth acre each. Only one of these beds is used at a time, the others resting meanwhile.

Mr. Keegan states that the new plant has been planned and constructed by him. The cost of the new septic tank, settling tank, and filter beds is about $4,000. The sewers do not serve more than one-half the present population. The average daily quantity of sewage is estimated as 400,000 gallons. The outlet pipe is 12 ins. in diameter, has a fall of 0.5 ft. per 100 ft., and does not run full except in very wet weather.

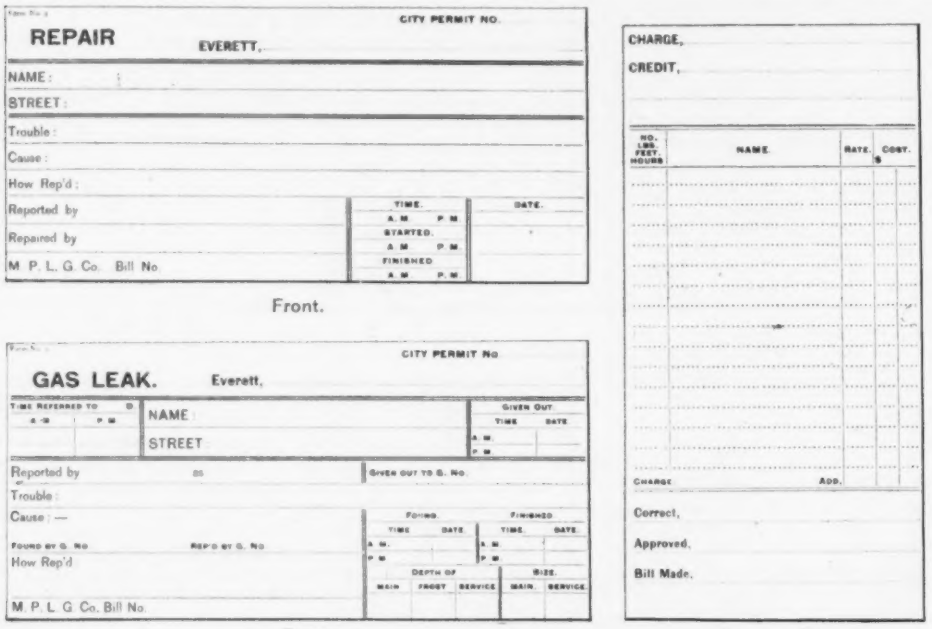


EXHIBIT XI. LEAK AND REPAIR SLIPS.

(On slips 7 ins. wide and 3½ ins. high, the reverse of each slip being alike.)

THE NEW YORK RAPID TRANSIT RAILWAY.

XI.

Contract Section V-a.

Contract Section V-a of the New York Rapid Transit Railway extends from the center lines of 41st St. and Park Ave. to 42d St., thence along 42d St. to Broadway, and thence along Broadway to the center line of 47th St. It has two sharp curves, one at Park Ave. and 42d St. and the other at 42d St. and Broadway, as shown in sketch plan by Figs. 47 and 48. The subcontractor for the work was the Degnon-McLean Contracting Co., of New York city, who began work on Feb. 25, 1901. This delay in beginning work was owing to negotiations with the New York Central & Hudson River R. R. Co. looking to the building of a joint station at 42d St., so as to permit the running of New York Central trains through the subway. The negotiations resulted in the railway company declining to co-operate with the Rapid Transit Commission.

MATERIALS PENETRATED.—The subsoil under 42d St. and Broadway throughout the greater part of Section V-a consists of a layer of earth from 5 ft. to 15 ft. deep overlying rock. The top part of the earth layer consists generally of rubbish, while the bottom part is glacial drift approaching the nature of hardpan in places. Between Sixth Ave. and Broadway on 42d St. there was a considerable distance through which the excavation penetrated earth entirely. The rock below the earth layer was of a somewhat heterogeneous character, but was generally mica-schist in strata dipping about 45° west and north. At intervals the rock was soft, and in many places it had a soft top portion or cap, but generally it was hard enough to serve as material for broken stone, and much of it was crushed and used in making concrete. Generally speaking, the top of the subway excavation was in earth and the bottom was in rock.

STREET AND ADJACENT STRUCTURES.—At Fifth Ave. there is a summit in 42d St., and from it the street surface dips both ways to the ends of the section. The street structures comprised a 48-in. water main, sewers and various other conduits; a double-track conduit electric railway along 42d St., another along Broadway, a third crossing 42d St. at Sixth Ave., and a fourth curving into 42d St. from Park Ave., and, with a single track, off 42d St. at Vanderbilt Ave. At Sixth Ave. the Manhattan Elevated R. R. crosses 42d St., and the line and station columns come directly over the roof of the finished subway structure. The streets along the section are bordered by buildings, a number of which are of great height, and the deep vaults of several of which encroached upon the space designed to be occupied by the subway. One of these vaults, a large bank vault, was located at the southeast corner of 42d St. and Fifth Ave. This vault extended 6 ft. beyond the curb for 140 ft. along 42d St., and also extended about 18 ft. over the subway structure at a height of about 8 ft. above the subway roof. This vault was very heavy, and was supported intact during the construction of the subway as follows: The vault, being on the south side of 42d St., the subway, structure on the north side was first built. I-beams 24 ins. deep and spaced 5 ft. apart were inserted transversely underneath the vault foundations. The north ends of these I-beams rested on the completed subway structure and the south ends were set into the rock face of the excavation just south of the future south wall of the subway. These I-beams held the vault until the full width of the subway was completed. In one instance at Broadway, the subway passed directly in contact with the foundations of a steel skeleton structure of considerable height and very small ground plan. The street traffic along all portions of the route is very heavy, there being an elevated railway station at Sixth Ave., and an elevated station and the Grand Central Station of the New York Central & Hudson River R. R. at the junction of Park Ave. and 42d St., to and from which the streets occupied by the subway work are the principal thoroughfares. Finally, for about 500 ft. the south wall of the subway on 42d St. comes close to and below the old wall of the 42d St. reservoir. The support of these various structures and the maintenance of the street surface for traffic were perhaps the most difficult tasks to be accomplished in building the subway of Section V-a.

SUBWAY STRUCTURE.—The Rapid Transit Railway structure throughout Section V-a is the standard four-track subway construction except for a portion of the work at the east end. This standard structure has an outside width of 54 ft. 4 ins.; 42d St. being 40 ft. wide between curbs and 100 ft. wide between building lines. Beginning at 41st St., the subway curves west into 42d St., then pursues a nearly straight line to Broadway, where it curves north and follows Broadway to the end of the section at 47th St. There are stations at Madison Ave. and at Broadway. Figs. 54 and 55 show the curves and the adjoining stations in plan.

Along 42d St., between curves, the south side of the subway approaches the building line closely, but its north side scarcely reaches to the north curb line of the street, except at the Madison Ave station, where the additional width brings the structure too near the building line on both sides of the street. This unsymmetrical location of the subway with reference to the center line of 42d St. was dictated, first, by the desirability of having curves of long radius at the Broadway turning; second, because it took up less private property under the sidewalks, and, third, because the traffic being heavier on the north than on the south side of 42d St., it resulted in less inconvenience to travel to concentrate the excavation on the south side.

The grade of the subway track is generally rising to Sixth Ave., and then generally falling to 47th St. From Madison Ave. to Sixth Ave. it is unbroken and .05%, while, as already stated, the street surface has a summit at Fifth Ave., about midway between Madison Ave. and Broadway. These relative grades brought the top of the subway some 22 ft. below the street surface at Fifth Ave., and only 7 ft. below at Sixth Ave.

Mention was made above that a portion of the structure at the east end of the section was not the standard four-track subway construction. As previously described, Contract Section IV. ends at the center line of 41st St., and consisted of two parallel double-track tunnels. The west tunnel ended at the center line of 41st St., and at that point standard subway construction began. The

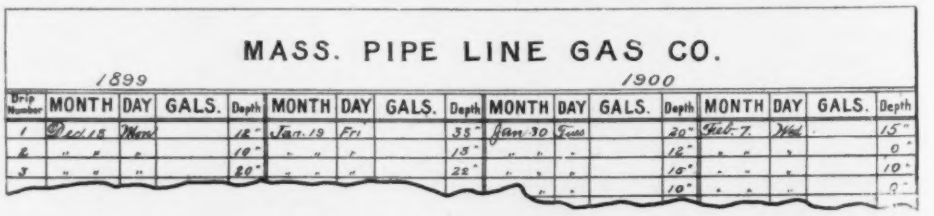

MASS. PIPE LINE GAS CO.
1899
1900
Drip Number
MONTH
DAY
GALS.
Depth
1 Dec 18 Mon 18" Jan. 19 Fri 35" Jan 30 Tues 20" Feb. 7. Wed 15"
2 " " " 18" " " " 13" " " " 16" " " " 0"
3 " " " 20" " " " 22" " " " 15" " " " 10"
" " " 19" " " " 9"

EXHIBIT XII. RECORD OF PUMPING DRIPS, WITH GALLONS AND DEPTH OF DRIPPINGS.

(On sheets 9 ins. wide and 4 ins. high.)

east tunnel continued some 75 ft. beyond the center line of 41st St., before structural subway construction was begun. This 75 ft. of two-track tunnel at the east end of Section V-a, therefore, constitutes the portion before mentioned as not being of the standard subway construction. It has a cross-section similar to that of the main tunnel, which it continues, but one of gradually increasing dimensions, owing to it being on a curve.

METHODS OF WORK.—The method of excavation and of erecting the subway structure differed

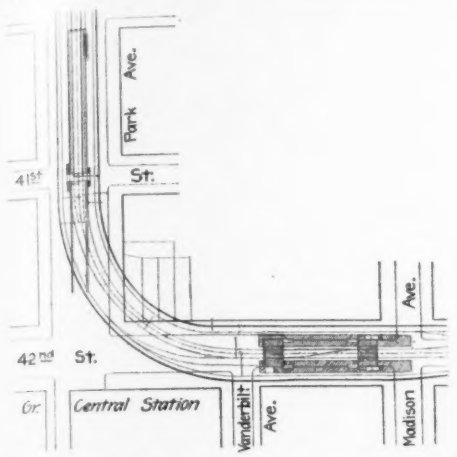


Fig. 55. Plan of Park Ave.-42d St. Curve and Adjoining Station.

with the different surface and subsurface conditions. Generally speaking, however, the excavation was performed by opening a trench on one side of the street and drifting under the street surface, which was supported in place, until the full width of the subway had been opened. With this general explanation the different methods of work will be described in order, beginning at the east end of the section.

EAST END TO FIFTH AVE.—A glance at the sketch plan, Fig. 55, will show that the west pair of tracks emerging from the west tunnel of Section IV. curves under private property to reach 42d St. The buildings under which the tracks ran were condemned and torn down, and the subway was built in open cut. The east pair of tracks continues in tunnel about 75 ft. further than does the west pair of tracks. This tunnel was built in open cut. The station and subway from the end of the curve to Fifth Ave. was built substantially as follows:

Between the Park Ave. curve and Fifth Ave. the subway excavation had to be made unusually wide to provide for the station, and a fifth track introduced for switching and transfer operations. The excavation extended to a depth of about 35 ft., and of this depth the bottom 10 to 15 ft. were in rock. Fig. 57 explains the sequence of operations.

A trench, A, was first opened on the south side of the street to subgrade depth and wide enough to permit of the erection of two bays of the steelwork. This trench was sheeted and braced in the usual manner, and the two bays of subway were completed as shown by Fig. 57a. The next step was to start transverse drifts, B, from the north side of the trench. These drifts were made about 12 ft. wide, were located about 50 ft. apart, and were made long enough to reach beyond the columns of the fourth bent of the subway structure. Their tops were kept well above the subway roof line, and their bottoms were carried to rock surface; they were timbered and sheeted. When a number of the transverse drifts had been completed, their north ends were connected by a longitudinal drift, C (Fig. 57b), having the same top and bottom levels. Work was next begun deepening drifts B and C through the rock to subgrade. At the bottom of drift C the concrete subway floor was laid, and on it was erected the fifth row of columns.

The next operation was to widen drift B so as to permit the placing of the 25-ft. roof beams connecting the third and the fifth row of columns. The widening was accomplished by breaking down both sides of each drift under poling boards, driven ahead and supported by vertical posts, until the headings met and left the entire space between drifts open as indicated at D (Fig. 57b). The roof beams were then erected and work was begun removing the rock cover, E E, to complete

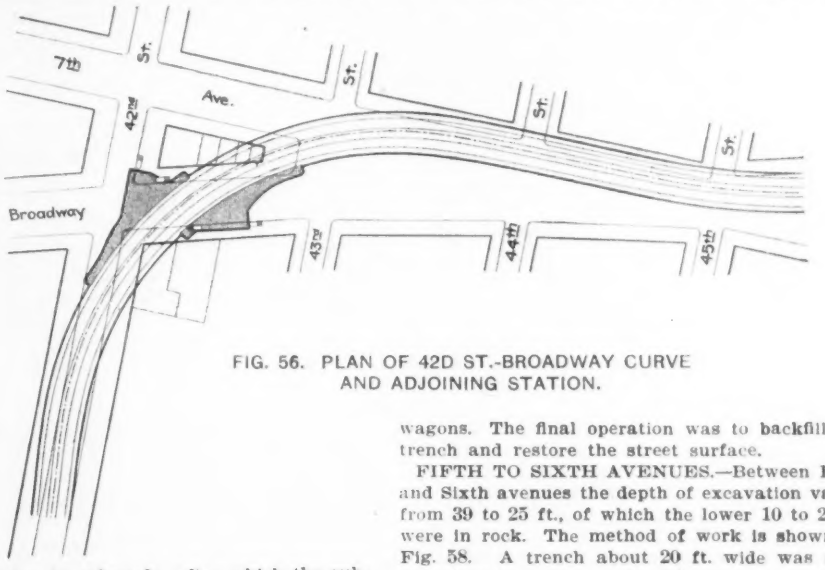


FIG. 56. PLAN OF 42D ST.-BROADWAY CURVE AND ADJOINING STATION.

the excavation to subgrade, after which the subway floor was placed, the fourth row of columns erected, and the concrete roof placed. Excavation was then begun for the fifth bay of the subway by extending the original transverse drifts B and widening them out until the entire space was cleared above the rock surface. The rock was then removed to subgrade and the fifth bay of steel and concrete erected as fast as room was made for it.

The erection of the steelwork and the placing of the concrete roof arches and jack arch sidewalls was complicated only by the restricted space in which the work was done, and was performed by ordinary methods. As fast as the subway roof was completed brick or rubble walls or piers were built on it over the roof beams to support the poling boards, which were left in place, and all open

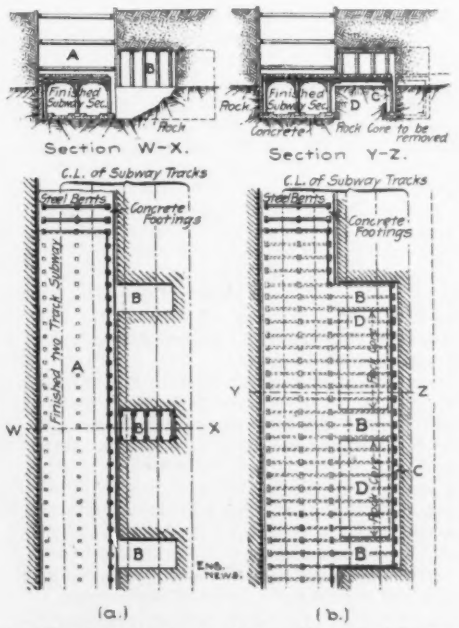


Fig. 57. Sketch Plan Illustrating Method of Excavation East of Fifth Ave.

spaces were packed with earth and stone. To remove the spoil a track was laid along the bottom of the opening trench A. Transverse branch tracks along the bottoms of the drifts B connected by turntables with the main track. At intervals holes were left in the subway roof over the main track, and a Carson-Lidgerwood cableway on the surface commanded the trench and these holes. In operating this system, the spoil was wheeled to the transverse tracks and loaded into small cars, which were then taken to the main track and along it to beneath one of the openings in the subway roof, through which the car boxes were lifted by the cableway and dumped into wagons. The final operation was to backfill the trench and restore the street surface.

FIFTH TO SIXTH AVENUES.—Between Fifth and Sixth avenues the depth of excavation varied from 39 to 25 ft., of which the lower 10 to 27 ft. were in rock. The method of work is shown by Fig. 58. A trench about 20 ft. wide was sunk to subgrade on the south side of the street and sheeted and braced where necessary in the usual manner. Along the bottom of this trench the south bay of the subway was erected complete except for holes in the roof at intervals to permit of the removal of the spoil from succeeding excavations.

At intervals of about 100 ft. transverse drifts, about 12 ft. wide, with their bottoms on the rock surface and their tops well above the subway roof line, were driven into the north side of the opening trench to a point about on line with the third row of columns. This drift was sheeted and timbered. A pair of 10 × 10-in. beams was laid on the subway roof about over the second line of columns to serve as a support for the rear ends of three I-beam needles, which were inserted endwise into the drift, about 5 ft. apart. The front ends of these I-beams were supported by vertical posts resting on the rock bottom of the drift. Wedges were inserted between the roof sheeting of the drift and the tops of these I-beams, and were driven tight so as to take the load off the temporary drift strutting and transfer it to the needles; the temporary strutting was then removed. Fig. 58a shows the needles in position, as described above.

The next process was to widen the drifts. This was done by removing the side sheeting and breaking down the east and west walls. The excavation was carried on under roof poling boards driven over the top flanges of the needles, as shown by Fig. 58b. When the excavation had proceeded far enough (about 6 ft.) another I-beam needle was inserted parallel to the first ones and was supported at the ends in a similar manner. The excavation was continued in this manner and new needles were inserted until a sufficient width had been opened up to permit the excavation of the rock bottom of the drift to subgrade and the erection of a second bay of the subway structure. Ultimately, of course, the widening operations joined the consecutive drifts and cleared the whole space necessary for the erection of the second bay of the subway.

To clear the space for the third bay of the subway the original drifts were extended and strutted to a distance well beyond the fourth line of columns. Work was then begun sliding the I-beam needles forward. The first step was to build rubble walls on the completed roof of the second bent to support the roof poling boards, as indicated by Fig. 58c and Fig. 58d. A timber was then placed parallel and close to each of the three I-beam needles, and was jacked up until it took the roof load off the needle. The three needles were then slid forward into the extension of the

drift until their rear ends rested on a pair of 10 × 10-in. timbers about over the third row of columns, and their front ends on posts, as shown by Fig. 58c. The roof sheeting was then wedged up on the tops of the needles and the drift strutting was removed. The succeeding operations were the widening of the drift in the manner previously described, the removal of the underlying rock to subgrade and the erection of the third bay of the subway.

The mode of procedure in building the fourth bay of the subway was a repetition of the proed from subgrade to the street surface. In length they cleared the full width of the subway structure. Their dimensions and locations were such that three bents of the subway for its full width could be erected complete in each. When this was done brick piers were built on the subway roof to carry the car tracks, pipes, conduits, and the stringers supporting the 4-in. planking. The cores of earth between drifts were then removed and the remaining subway bents were erected in the spaces thus opened. These bents were in turn capped with brick piers and filled

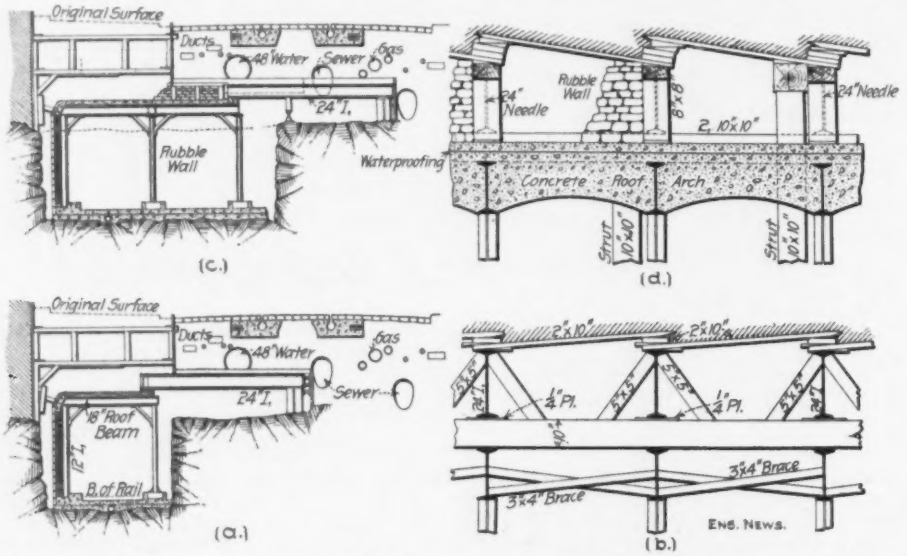


FIG. 58. SKETCH PLAN ILLUSTRATING METHOD OF WORK BETWEEN FIFTH AND SIXTH AVENUES.

cesses described. The drift was extended, the needle beams slid forward and the drift was then widened and deepened and the subway structure was erected.

To handle the spoil a track was laid along the bottom of the side trench, and from it cross tracks were extended into the drifts. As the drifts were widened branches were run both ways from the drift track to the working faces, as indicated by the diagram sketch Fig. 59. The cars from the working face were run onto the main track to the points where the roof of the first subway bay had been left open, and then their bodies were hoisted to the surface and dumped by a Carson-Lidgerwood cableway, which commanded the trench.

SIXTH AVE. TO BROADWAY.—Between Sixth Ave. and Broadway the excavation was almost wholly in earth, and two methods of work were adopted, one for the middle portion of the block and the other for the two end portions. For the portion in the middle of the block a trench about 20 ft. wide was sunk to subgrade on the south side of the street. This trench was sheeted and braced in the usual manner and was roofed over

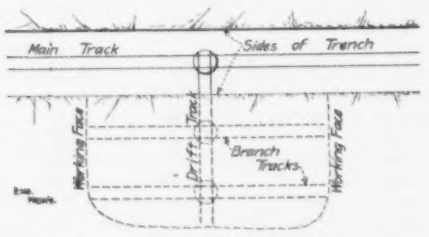


Fig. 59. Sketch Plan Illustrating Arrangement of Spoil Tracks Between Fifth and Sixth Avenues.

in part to carry the sidewalk traffic. On its bottom the first bay of the subway structure was erected. The paving was then removed between the outside rails of the car tracks and the curbs on each side of the street, and was replaced by a transverse planking of 4-in. plank laid on 10 × 12-in. longitudinal timbers 30 ft. long. Two longitudinals were used on each side of the street. Drifts about 12 ft. wide and 25 ft. apart were then driven across the street from the north wall of the trench. These drifts were sheeted and strutted, and in vertical height extendabove with packed earth and stone. To remove the spoil a track system and cableway similar to those described for the preceding blocks were used. The cableway was supplemented in places by stiff-leg derricks.

The mode of procedure at the ends of the block was to sink and sheet a 20-ft. trench to subgrade as the first operation. From the north side of this trench near the top narrow drifts about 10 ft. apart were carried under the street railway foundations and needles were inserted and wedged up against the concrete. Excavation was then begun by breaking down the north face of the trench on an angle sloping upward from subgrade, as shown by Fig. 60. As the excavation cut under the needle beams they were shored up by inserting longer and longer posts, until finally their opposite ends were carried on posts resting on subgrade, as shown by Fig. 60. While the undermining of the street railway track was in progress from the south trench, work was begun building a platform flush with the street surface on the north sides of the tracks. To do this the pavement was first removed and shallow trenches opened in the subsoil parallel to the tracks, in which timber stringers were laid. On these stringers was laid a flooring of 4-in. plank running crosswise of the street. As the excavation from the south extended under this platform, posts were inserted to support it, as indicated by Fig. 60. When the whole width of the subway had been cleared the subway structure was erected and brick piers were built over alternate bents to carry the street railway foundations. The succeeding operations of filling the voids above the roof, backfilling the trench and restoring the street surface completed the work. In excavation the spoil was taken from the working face to the main trench in cars and thence hoisted by cableways and derricks and dumped into wagons.

BROADWAY TO 47TH ST.—In passing from 42d St. into Broadway the subway curves under private ground occupied by a building that had to be removed and replaced by other structures. This building has to be underpinned and temporarily supported during construction. Along Broadway the covering over the subway is comparatively shallow, being usually from 3 ft. to 5 ft. One side of the street is opened to subgrade and then one bay of the subway is erected. The remaining excavation is then made the full width, sin[illegible] only the surface tracks are to be supported, and when necessary the street is boarded over to carry the traffic.

STREET CROSSINGS.—At some of the streets crossed by the subway the presence of surface and subsurface structures made it necessary to depart from the straightforward method described as having been used between blocks, but the general plan of drifting under and supporting the street structures intact was adhered to. At Sixth Ave., particularly, the work was much complicated, since six columns of the elevated railway and station and the station stairways on the south side come directly over the roof of the subway structure. These columns and stairways had of course, to be temporarily supported during the construction of the subway. The general method adopted was the same for all supports, but the details differed for each. The general method was as follows: Two parallel plate girders were supported at their ends on timber bents or horseheads erected in pits sunk in the street. The column to be supported passed down between these girders near the center of their span and was fastened to them by bracket plates crossing the girders transversely and bolted to their top flanges and to the column on opposite sides, as indicated by the sketch, Fig. 61. When the column had been supported in this manner the excavation and the erection of the subway structure proceeded. As soon as the roof of the subway was completed a pier was built on its top to serve as a foundation for the column, after which the horseheads, girders and brackets were removed. As stated above, the number and arrangement of the horseheads and the disposition of the other parts of the temporary support differed in each case to meet differences in space available, subsurface conditions, etc. The general method of support was the same in all cases, however, and proved entirely satisfactory.

PIPES AND CONDUITS.—The maintenance of street pipes and conduits on Section V-a called for special provisions in several cases. Along 42d St., where the depth of the subway roof below the street surface was considerable, the methods of excavation adopted relieved the contractors of the necessity of handling any but the deepest and largest conduits. Where the subway roof approached the street surface more closely, means had, of course, to be taken to support the various conduits. Generally it was found possible to do this from the timbering and strutting of the excavation. In some instances also the conduits were rebuilt in a new location clear of the subway work. The most notable of these changes was the removal of a 48-in. water main from 42d St. to 40th St. This main ran along 42d St. and was over 30 years old and liable to break easily. To provide against such a break, which would ob-

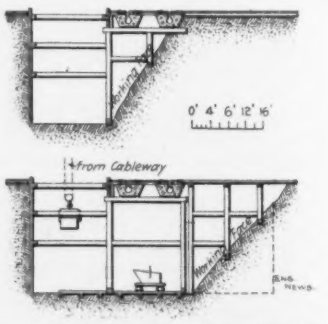


Fig. 60. Sketch Sections Illustrating Method of Work Between Sixth Ave. and Broadway.

viously be something of a catastrophe, the contractor before beginning the subway work built a new main on 40th St. and the use of the old main was discontinued. Another piece of work of similar character was the removal of a portion of the 42d St. sewer near Park Ave. to 41st St.

At Madison Ave. a 48-in. water main had to be carried across the subway excavation. This was done by building two parallel triangular trusses across the excavation and hanging the main in chain slings from the floor beams laid on the bottom chords of these trusses. At Fifth Ave. there

TABLE II.—STEAM CONSUMPTION OF SULZER COMPOUND ENGINES.

Location of engine.	Type of engine.	Normal I. HP.	Diameter of cylinders H.-P. mm.	Diameter of cylinders L.-P. mm.	Stroke, mm.	Revolutions per min.	Initial pressure, atm.	Steam temperature at entrance H.-P. cyl., degs. C.	Vacuum, cm.	I. HP.	Steam consumption Per I. HP. hour kilos.	Per I. HP. hour lbs.	Per B. HP. hour kilos.	Per B. HP. hour lbs.	Per KW. hour kilos.	Per KW. hour lbs.	Efficiency of engine.	Combined efficiency of dynamo & engine.
Elect. Sta., Frankfort-on-Main	Tandem.	1,500 to 1,800	775	1,250	1,500	85	9.17	180	67	850	6.05	13.3	6.76	14.90	9.67	21.30	0.895	0.851
							9.25	220	67	842	5.47	12.05	6.14	13.52	8.84	19.48	0.891	0.842
							8.54	250	67.5	1,719	5.04	12.42	6.01	13.24	8.50	18.72	0.939	0.903
Electrical Station, Zurich.....	Tandem.	1,050 to 1,250	680	1,100	1,300	100	7.6	235	68	1,167	5.95	13.10	6.25	13.77	8.95	19.72	0.951	0.904
Electrical Station, Mannheim.....	Tandem.	800 to 1,000	610	1,025	1,300	83	9.6	180.4	71	481.5	5.9	13.00	6.66	14.68	9.67	21.30	0.886	0.830
							9.4	180.1	71	750	5.95	13.10	6.42	14.14	9.23	20.35	0.926	0.877
							9.5	182.2	70	1,078	6.40	14.10	6.79	14.95	9.76	21.30	0.932	0.892
							9.5	286	71	515	5.14	11.32	5.76	12.70	8.48	18.69	0.894	0.824
							9.3	278.2	70.5	788	5.23	11.52	5.62	12.38	8.12	17.90	0.931	0.875
							9.4	285	69	1,100	5.40	11.88	5.68	12.50	8.14	17.92	0.951	0.902
Electrical Station, Mayence.....	Tandem.	950 to 1,150	660	1,075	1,300	86	9.15	181	71.7	1076.5	6.4	14.10	6.73	14.82	9.65	21.25	0.951	0.902
							9.10	181	71	1,316	6.58	14.50	6.85	15.10	9.78	21.55	0.960	0.915
							9.3	258	72	1,071	5.33	11.73	5.69	12.53	8.03	17.70	0.951	0.903
							9.6	275	..	1,021	6.98	15.37	7.40	16.30	10.62	23.40	0.943	0.893*
Metalwarenfabrik Geislingen Wirthemberg	Tandem.	400 to 500	450	775	900	110	9.5	303	67	519.5	4.9	10.80	.....	.....	.....	.....	.....	.....†
							9.5	290	67	347	4.7	10.35	.....	.....	.....	.....	.....	.....
Neue Baumwollspinnered Hof, Bavaria.	Tandem.	1,000 to 1,200	682	1,200	1,700	65	8.9	346	69	788	4.5	9.91	.....	.....	.....	.....	.....	.....
							8.9	351	69.1	797	4.39	9.68	.....	.....	.....	.....	.....	.....
							9.0	300	66.8	788	4.86	10.70	.....	.....	.....	.....	.....	.....

Note.—The type of engines in the two last named places are tandem with intermediate superheaters.
*Non-condensing. †Intermediate superheating; temperature of steam at entrance of low-pressure cylinder, 176°, 166°, 153°.

were two 48-in. and two 36-in. water mains across the excavation. They were carried on posts and needles, forming a trestle properly stiffened with diagonal bracing. At the Sixth Ave. and Broadway crossings the congestion of pipes and conduits was unusually great, but no difficulty was found in handling them by ordinary means of support.

DISTURBANCE OF TRAFFIC.—Considering the intensity of the traffic along the streets occupied by the work of Section V-a and the difficulties of that work, the disturbance of the street traffic by it was exceedingly small. This was due largely to the fact that practically the only opening made in the street surface was on the south side, and between the building and curb lines. This opening pretty completely interrupted the south sidewalk, of course, but for the stretch between Fifth and Sixth avenues bordering Bryant Park this did not matter much, and the liberal provision of sidewalk platforms and stairways elsewhere did much to maintain the original conveniences. The advantage of the arrangement was the entirely undisturbed condition of the whole street from the south curb line to the north building line, which left it as free as ever to the street and sidewalk traffic.

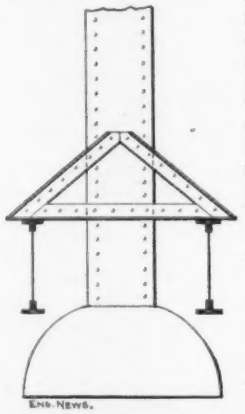


Fig. 61. Sketch Showing Method of Supporting Elevated Railway Columns at Sixth Ave.

PLANT.—The contractors of Section V-a secured their power from the same plant which supplied Section IV., and which has already been described in connection with the work on Section IV. Compressed air was used to operate all hoisting engines, cableways, pumps and other machinery, as well as the drills.

The entire work of Section V-a has been in charge of the following engineers: Mr. Alfred Craven, Division Engineer for the Rapid Transit Commission, and Mr. H. C. Sanford, Engineer for the Contractors.

STEAM CONSUMPTION OF SULZER ENGINES WITH SUPERHEATED STEAM.

We have received from Messrs. Sulzer Bros., Winterthur, Switzerland, the two tables given herewith, showing the steam consumption of some of their recent compound and triple expansion engines with saturated and with superheated steam. The tests were made by Prof. Schroeter, of Munich; Prof. Weber, of Zurich, and other eminent engineers. It is to be regretted that no similar tables have yet been published by any American engine-builder, and we doubt if any engine yet built in America can equal the performance shown by some of these tests. The peculiar features of the Sulzer engine are long stroke, high piston speed, reaching sometimes nearly 850 ft. per minute, and balanced poppet valves with small clearance. This type of engine has been built in Europe for over 30 years. It is strange that it has not yet been adopted in this country. The poppet valve is peculiarly adapted to the use of superheated steam.

TABLE III.—Metric Figures in Table II. Translated into English Units; Steam Consumption of Sulzer Compound Engines.

Normal HP.	Diameter of cylinders. H.-p., ins.	L.-p., ins.	Stroke, ins.	Revs. per min.	Initial pressure, lbs.	Temp. of steam entrance of H.-P. cylinder, ° F.	Vacuum, ins.
1,500 to 1,800	30.5	49.2	59.1	85	120.1	356	26.4
					121.3	428	26.4
					110.8	482	26.6
1,050 to 1,250	26.8	43.3	51.2	100	97.0	455	22.9
800 to 1,000	24.0	40.4	51.2	83	126.4	356.7	28.0
					123.5	356.2	28.0
					125.0	356.4	27.6
					125.0	546.8	28.0
					121.0	532.8	27.8
					123.5	545.0	27.2
950 to 1,150	26.0	42.3	51.2	86	119.8	357.8	28.2
					119.1	357.8	28.0
					121.0	496.4	28.3
					125.0	527.0	....
400 to 500	17.7	30.5	35.4	110	125.0	577.4	26.4
					125.0	554.0	26.4
1,000 to 1,200	26.9	47.2	66.9	65	116.1	654.8	27.2
					116.1	663.8	27.2
					117.6	572.0	26.3

ANNUAL CONVENTION OF THE CENTRAL STATES WATER-WORKS ASSOCIATION.

The sixth annual convention of this association was held at Indianapolis, Ind., Sept. 23 to 25, the headquarters and place of meeting being at the Denison Hotel. The attendance was good, but there was little discussion of the papers read, although most of them were short papers of a practical character. This was partly due, no doubt, to the fact that the papers were not printed in advance, and even the titles were not announced on the program for the meeting.

The first session was called to order at 2.30 p. m., Sept. 23, and after the usual order of opening business the first paper was read by Mr. C. W. Wiles, of Delaware, O., an abstract of which is given herewith:

The practice of drawing water from fire hydrants for street sprinkling wagons has been adopted in most cities to a greater or less extent. The value of the water so taken is computed in various ways. Very often the street is measured and a charge made per lineal foot per month or for the season; in other cases a record is kept of the number of loads of water taken daily, and charge made accordingly. The latest and most approved method is to attach a suitable meter to each wagon (using one with a capacity equal to the stream taken from the hydrant), and to then make a charge per 1,000 gallons of water taken. By this method, streets that require but little water can be sprinkled occasionally and those requiring more attention can be sprinkled as often as necessary, and the wagon made to cover more streets. The average driver of a sprinkling wagon puts too much water on the street, the water running to the gutters on paved streets or making mud on unpaved streets.

The ordinary charge by contractors is from 1 to 2 cts. per ft. of frontage per month; this is payable by the property owners on the street, and if not paid it can be assessed upon the property as taxes.

A law has recently been enacted in Ohio which places the street sprinkling in the hands of the city authorities, and on petition of 35% of the voters the city council can order such streets sprinkled as they think best, the actual cost of the sprinkling being placed upon the general city tax duplicate. This is upon the theory that street sprinkling is of general benefit, the same as street cleaning and lighting. In some cities that have adopted this method during the past season, the city has purchased sprinkling wagons and hired drivers who own teams, paying the usual price per day for team work. This has proved very satisfactory, and is no doubt the most economical method for the people, as they get the streets sprinkled at actual first cost, which in some cases has been as low as ½-ct. per ft. front per month. If the city owns the water-works that department should have credit for the value of the water taken, the same as if owned by a company. In some cities with well-paved streets fairly well cleaned, each sprinkling wagon can cover about four miles; but for dirt or macadamized streets, not often cleaned, two wagons will often be required for the same distance.

There was no discussion on the paper, and it was followed by a paper on "Flushing Water Mains," by Mr. John Langan, of Tipton, Ind. He explained the ill-effects of too frequent flushing from the hydrants, etc., and described his own methods. Mr. Charles, of Lexington, Ky., referred to the inefficiency of flushing from hydrants, a point which was also referred to in a paper presented by him later and noted below.

The next paper was by Mr. C. E. Inman, Superintendent of the Warren Water Co., Warren, O., an abstract of which follows:

RATES FOR AUTOMATIC SPRINKLING.

There are certain perplexing conditions in the furnishing of water and the establishing of rates for automatic sprinkler systems, and there seems to be a vast difference in the minds of water-works superintendents regarding the charge for these systems. The people who install these systems (the General Fire Extinguisher Co.) argue that water is only used in case of fire and then in less quantity than if the sprinklers were not installed, and that therefore the water company should not make any charge. The manufacturers also make similar arguments. The insurance companies require a large pipe direct from the mains to the sprinkler system, free from any hindrances to the free flow of water, and they object to having meters placed on the pipe.

I wrote to several superintendents in Ohio asking for

TABLE I.—Steam Consumption of Sulzer Triple Expansion Engines.

Location of engine.	Type of engine.	Normal power, I. HP.	Diameter of cylinders—High, ins.	Int., ins.	Low ins.	Strke, ins.	Revs. per min.	Initial pressure, lbs.	Steam temperature at entrance H.-P. cylinder.	Vacuum. ins.	I. HP.	Steam consumption per I. HP. hr., lbs.
Moabit Electr. Sta., Berlin	Hor., 4-cyl., triple exp.	3,000	32¼	47¼	58	59	85	188	319° C. 606° F.	28	2,860	8.97
								190	203° C. 397° F.	27¼	2,880	11.28
Louisenstrasse Elec. Sta., Berlin	Vert., 4-cyl., triple exp.	3,000	34	49	61	59	83½	189	323° C. 613° F.	27	2,908	9.41
								196	194° C. 381° F.	26¼	3,040	11.57

their charge for such service. One town had a book rate of $8 per quarter for each 10,000 sq. ft. of floor space, but the superintendent wrote that they were considering the advisability of charging meter rates. One superintendent had had only one call for a sprinkler supply, and had charged one-third of the amount saved on the insurance policies. Another had all such services metered. Still another replied that the question was made very troublesome by the insurance companies. He thought all such services should be metered, or a rate of 15 cts. per sprinkler head per annum was reasonable.

It would seem that such questions should be settled on some uniform basis by water-works managers, but they are passed over and the holders of insurance policies get the service free in many cases, because the cities give it to them at the expense of the taxpayers. The insurance companies draw good premiums and the policy holder has his insurance cut to about one-third after the service is established, yet both claim that the parties furnishing this service should receive no compensation.

Many, if not all, city-owned plants furnish this fire protection free, and on this basis sprinkler service might be made free also. One trouble, however, is that the gift is abused and water is drawn from these pipes for other purposes. Water companies which sell water for domestic use, being bound by their franchise, cannot afford to run chances of being defrauded in this way, and my object in presenting this paper is to try and have some uniform rate brought about by this association. I am told by a gentleman who installs sprinkler systems that the insurance rate is reduced at least 40%, and in many cases even more.

There was some discussion on this paper, in which Mr. F. A. W. Davis, of the Indianapolis Water Co., remarked that when looking into this matter about six years ago he sent out 90 letters of enquiry to water-works superintendents; 84 replied that they knew the water from these fire services was used for other purposes, and 75 thought the service should be charged for. The charges ranged from $25 to $300, and averaged about $60. The city of Indianapolis charges $50 per year for 4-in. connections, $35 for 3-in., and $25 for 2-in., and also charges the cost of putting in the service. The reduction in insurance is so great, however, in comparison with these charges, that no objections are made. As to the equity of the charge, he thought there was nothing of greater importance given for such a small amount of money, and the American Water-Works Association has adopted resolutions declaring a charge for such service to be just and equitable. It must be ascertained, however, before putting in a sprinkler service that the mains are of sufficient size to justify it, and not leave other parts of the system without proper protection. There is almost always more or less surreptitious use of water from these fire services.

The President thought the association should take some action on this matter, and two resolutions were passed, as follows:

Resolved, That it is the sense of the association that those who have automatic sprinkler systems connected with the street service should pay an equitable amount for such protection.

Resolved, That it is the sense of the association that those having standpipes, hydrants and other private services placed in buildings for fire protection should pay for such service.

A paper describing "A Device for Measuring the Flow of Driven Wells Connected with a Common Suction Main," was then read by Mr. J. B. R. Maxwell, of Cincinnati. This consists of a horizontal wheel set in the well, below the suction main, and having a vertical shaft which extends to a meter placed on an extension of the well casing, which reaches above the ground. It has been used at Hamilton, O.

This was followed by a paper by Mr. S. A. Charles, of Lexington, Ky., which he prefaced by stating that the present reservoir capacity in his city is being enlarged to 600,000,000 gallons, with a water area of 200 acres. An abstract of this is given below:

PURIFICATION OF WATER AT LEXINGTON, KY.

Our first reservoir comprised about 120 acres of water surface with a capacity of 360,000,000 gallons. This was formed by a dam to impound the rainfall, there being no running stream, and there was trouble from the odor due to decomposition of algae and other vegetable matter. By passing the water through boxes of sponge a coarse straining was effected, but was of little value. The filter bed system was out of the question, as there was no land, money or sand available, and after considering the pressure and gravity filter systems the latter was adopted. A simple device consisting of an auxiliary pump driven by the main pump, serves to inject any desired proportion of coagulant. There still remains, as in most Southern climates, an odor from the decomposition of vegetable matter, and as this is due to a gas it cannot be filtered out. This is eliminated by aeration; at first jets of compressed air were employed, but the simple falling of the spray of water from a perforated tube to the filter below gives the desired result at much less expense.

Some algae would from time to time escape from the filter and lodge in the pipes, with subsequent trouble from their decomposition. This trouble has been entirely remedied by flushing. For this purpose the ordinary flushing at the hydrants, 3 ft. above the main, is not efficient. We have therefore put in washouts at the lowest points in our system, and each night some part of the system is flushed by means of these washouts, aiming to flush the entire system at least once a week, and oftener if necessary. To do this we have a man at the washout and assistants in other parts of the city, who, under his directions by telephone, open or close the proper valves.

In reply to enquiries, Mr. Charles stated that he uses sulphate of alumina as a coagulant, averaging about ⅓-grain per gallon for the entire year. The total expense for purification, including aerating, etc., is 1 ct. per 1,000 gallons.

The next paper was on "Fire Streams," by Mr. F. A. W. Davis. It discussed the loss of pressure due to friction and length of hose, and gave the different pressures required to throw 1¼-in. streams to a uniform height from hose of different lengths. Mr. Cook, of Toledo, said that firemen often made bad kinks in the hose, and then, finding the streams weak, claimed that the water pressure was insufficient. Tests such as those described in the paper should be made in order to demonstrate the actual facts to the firemen. Mr. Davis said that at Indianapolis a man from the water company attends at all fires and sees that the hydrants are properly open. Mr. Pater, of Hamilton, O., said that fire hydrants should never be placed on mains less than 6 ins. diameter, and 8 ins. is better, yet some towns use 4 ins. as their largest mains. In one case, the attempt to draw several streams from a 4-in. main so demonstrated the insufficient capacity that the insurance company demanded a 12-in. main, which would allow 6 and 8-in. pipes to be run through the property of an extensive manufacturing plant. This closed the proceedings of the first session.

On Wednesday morning the committee on badges made a report, and a button and form of certificate of membership were adopted. Mr. Pater, of Hamilton, O., exhibited the remains of a brass corporation cock which had been destroyed by electrolysis. All traces of copper had disappeared, leaving only a rough shell of the tin, which had been alloyed with the copper. Mr. Pray suggested that in view of the adoption of a new municipal code in Ohio, the Ohio members should get together and decide as to the best way in which the water-works interests should be provided for, and then bring the matter to the attention of their representatives in the State legislature. A resolution passed, on motion of Mr. Wiles, of Delaware, O., gives the associate members (agents of supply houses) the same rights as the active members in regard to voting and holding office. No opposition was made on the floor, but the step did not appear to meet with general approval afterwards.

The first paper was on "What is a Wholesome Drinkable Water?" by Mr. C. Monjeau, of Middletown, O., and proved to be a lengthy but vague dissertation comparing the course of water in the earth with the flow of blood in the veins.

A paper by Mr. Marshall O. Leighton, of the U. S. Geological Survey, Washington, D. C., was then read. An abstract of this is given below:

STREAM POLLUTION AND ITS PECUNIARY DAMAGE TO NATURAL WATER RESOURCES.

American cities have learned by dear experience that it is expensive to provide polluted drinking water. The cost of epidemics must be considered as well as the humanitarian aspect. Each life sacrificed and each day of illness occasioned represents a financial loss. Again, many manufacturing processes require the use of fairly pure water, and the water in lakes or streams in residential or park areas must be comparatively pure, or the value of property in the vicinity will be materially decreased. The pollution of the Passaic River, in New Jersey, below Paterson, is now such that the following conditions have been brought about:

1. The water supply intakes have been abandoned, and the supplies substituted will eventually cost $20,000,000.
2. The shad fisheries have been entirely destroyed.
3. The water can no longer be used to any extent in manufacturing, and it is very destructive to boilers.
4. There is little, if any market for the land immediately along the banks, as the country is practically uninhabitable because of the odors, etc. If this region could be relieved from the damaging conditions there would be an unprecedented increase in values, and they could now be almost entirely relieved by the expenditure of $6,000,000.

The Division of Hydrography of the U. S. Geological Survey has, as its principal duty, the consideration of the country's water resources. This consideration has been mainly as to the amount, and its availability for power and irrigation, etc. The character of the water, however, has such an important influence upon its value, that it is necessary to carry on investigations of this sort also. The removal of causes of pollution does not lie within the province of the Survey, but our present duty lies in the investigation of the enormous damages inflicted upon one of our finest natural resources.

It will be my endeavor, as the official in charge of this new branch of the survey work, to co-operate with every chemical laboratory where the analysis of water is conducted. It is desired to bring together the results of water examination for study and comparison, the examinations to be made according to standard methods. Coincident with this work the areas of special interest all over the country will be taken up and studied. This has already been accomplished in the metropolitan district around New York; similar work is now being carried on in the anthracite coal regions of Pennsylvania, and during the coming winter the drainage area of the Wabash River will receive attention.

The last paper of the morning session was by Mr. A. L. Holmes, of Grand Rapids, Mich., on "Submerged Pipe." We give an abstract of this elsewhere in this issue.

On the morning of Sept. 25, the closing session was held. The secretary was instructed to send to all water-works superintendents in the district covered by the association a blank form to be filled in with particulars of the works. Mr. L. C. Anderson, Consulting Electrical Engineer, of Franklin, O., gave a brief address on the subject of electrolytic corrosion of water mains.

OFFICERS AND PLACE OF MEETING.

The election of officers resulted as follows: President, Joseph J. Pater (re-elected), Hamilton, O.; First Vice-President, F. J. Kelly, Cincinnati, O.; State Vice-Presidents, F. Baker, Evansville, Ind.; W. H. Glore, Covington, Ky.; T. H. Molton, Nashville, Tenn.; A. L. Holmes, Grand Rapids, Mich.; S. F. Tompkins, Joliet, Ill.; and O. G. Guyton, Sistersville, W. Va.; Treasurer, Charles E. Rowe, Dayton, O.; Secretary, Wm. Allen Veach, Newark, O. The office of Editor was left unfilled, as being unnecessary, and it is proposed to amend the by-laws so as to abolish this office. The next meeting will be held at Dayton, O., in 1903.

ENTERTAINMENTS AND EXCURSIONS.

On Tuesday evening, a reception and "smoker" was given at the rooms of the Commercial Club. On Wednesday afternoon, a special train on the Belt Line took the party around a great part of the manufacturing part of the city, and to the new Riverside pumping station, where they inspected the pumping plant and the new coal-crushing plant for dust-fuel. Carriages then took the party to the site of the new filtration plant, the grading for which is in progress, and then to the Wabash canal. This is owned by the Indianapolis Water Co., and at present supplies power, but will be utilized as a source of water supply when the filter plant is completed. A steam launch and flat-boat took the party some miles up the canal, to Fairview Park, where special cars of the Indianapolis Street Ry. were in waiting for the return trip to the city. Some notes of the exhibits of water-works supplies are given in the supplement.

THE ELECTRIC SMELTING OF IRON ORE is said to have been effected at Gysinge, Sweden, and a paper describing the experiments was read in June before an association of iron manufacturers at Jernkontoret. The paper is abstracted in "Consular Reports" for September. It is stated that a 78-KW. generator produced steel at the rate of about 575 lbs. per 24 hours. A larger furnace was later built with nearly three times the capacity, but its efficiency is not stated. According to the accounts, steel was produced by the process direct from the ore. The experiments appear to have been made under the direction of an engineer named F. A. Kjellin.

WATER POLLUTION PREVENTION AND SEWAGE PURIFICATION IN THE MERSEY & IRWELL DISTRICT, ENGLAND.

Ten years ago the Mersey & Irwell Joint Committee was created in England to conserve the purity, or perhaps more correctly to restore it as far as possible, of a number of rivers in the vicinity of Manchester. The yearly reports of Mr. R. A. Tatton, M. Inst. C. E., Chief Inspector of the Committee,* describe the progress of this work, and from the report for April, 1902, the following statements have been taken:

The population in the district under the jurisdiction of the committee aggregates 2,456,723, located in 94 municipalities, of which latter seven have a combined population of 1,304,314.

Of these 94 municipalities, or "authorities," 86 had works for the treatment of sewage in operation in March, 1902, and three had works under construction, against only 27 works in operation and 8 under construction when the committee began its work in 1892. Of the five authorities without works in operation or under construction in 1902, one had obtained approval for works and one had works under consideration, leaving only three authorities that had taken no action.

On the face of these returns the status of water pollution by municipal sewage would appear to be remarkably good, but the tabular description of the disposal works in question shows that many of them are but makeshifts. Mr. Tatton states that while pollution by solid matter has been largely prevented

serious pollution is caused by the soluble putrescible organic matters which give rise to offensive emanations in warm and dry weather. Half measures for the purification of sewage are of little or no use—in fact, a partially treated sewage, which has been held up for some hours in tanks, and in which decomposition has advanced to some considerable extent, will cause more nuisance in the upper reaches of the stream into which it is discharged even than raw sewage in which the advanced stages of decomposition will not be reached until it has been diluted and brought in contact with the larger volume of the main rivers.

Progress in adopting methods for removing putrescible soluble matters is characterized by Mr. Tatton as slow and disappointing, but "the authorities are becoming more active in adopting filtration."

Regarding "biological filters," Mr. Tatton says: This method of treatment is being adopted more and more every day, and although it may never take the place of first-rate land treatment as far as efficiency is concerned, it is of great value where suitable land cannot be obtained, or where for other reasons it is undesirable to have a large expanse of land under sewage treatment.

Liquid trade wastes are one of the most serious troubles with which the committee has had to contend. On the River Mersey alone there are 445 manufactories, for which separate "purification" works are necessary, besides 250 which drain into the public sewers. Of these 445 manufacturing plants, 294 now have efficient and 139* have inefficient purification works, 5 have works under consideration and only 7 have adopted no treatment whatever. The figures are given in detail, according to the class of manufactory, in the accompanying table.

Kinds of works.	Works constructed—Efficient.	Works constructed—Inefficient.*	Under construction.	No treatment.	Total
Print	37	12	..	..	49
Dye	84	34	..	2	120
Bleach	54	17	2	..	73
Waste bleach	5	6	..	..	11
Paper	18	8	1	..	27
Paper stainers	3	1	..	..	4
Tanners and leather dressers	5	4	..	..	9
Fellmongers	1	4	..	..	5
Woolen trades	44	14	..	..	58
Silk	2	..	..	..	2
Slack washing	9	1	..	..	10
Soap	1	5	..	..	6
Stone polishers	7	2	..	..	9
Chemical	14	3	..	..	17
Breweries	8	7	1	1	12
Unclassified	7	21	1	4	33
Total	294	139	5	7	445

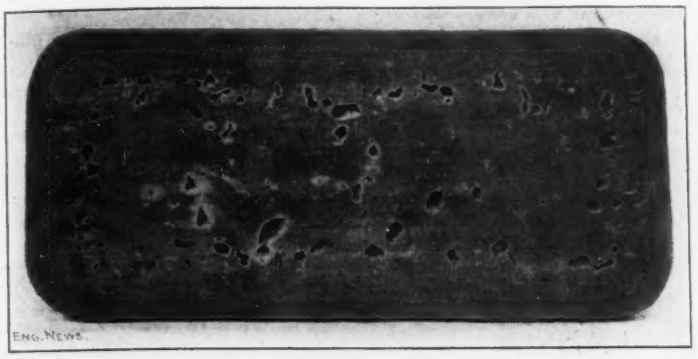
*Including many works where the surroundings are too limited to allow of efficient purification plant being put down.

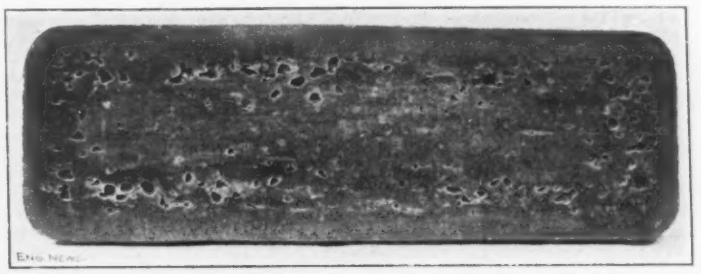
Pollution from solid industrial wastes has been reduced to small proportions. Dumping cinders into streams has been diminished because "in many places they are now of value for the construction of filter beds, either for purifying sewage or manufacturing wastes."

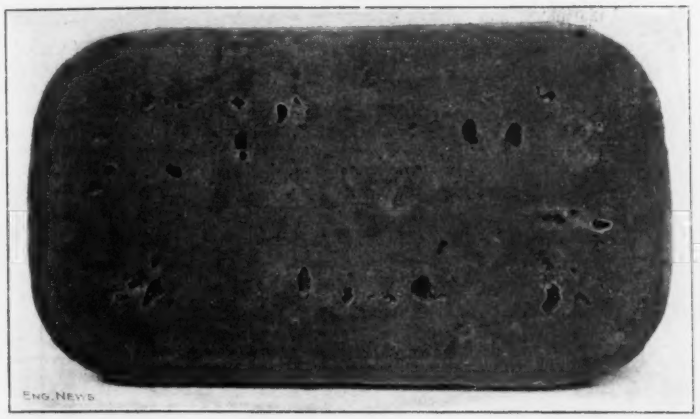
Those interested in the details of the municipal sewage disposal plants in the Mersey & Irwell district may find them in the form of tables on

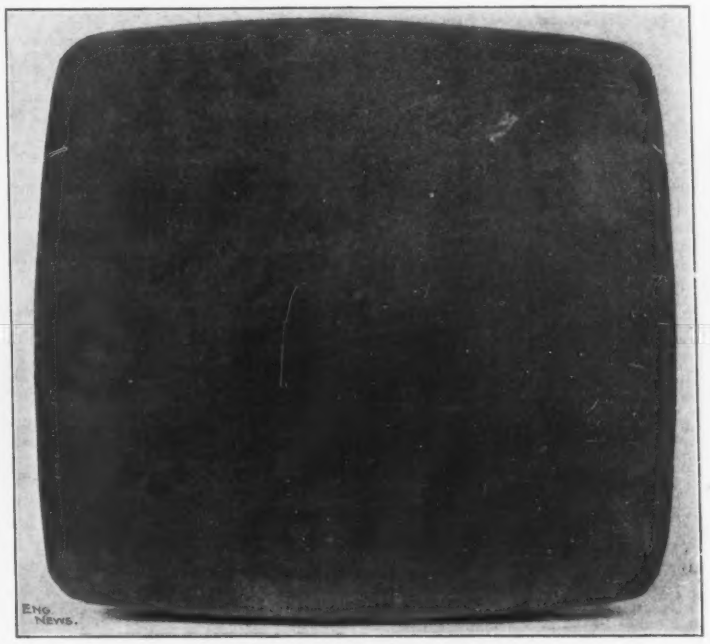
*See foot-note to table.

*44 Mosley St., Manchester, England.









ETCHED CROSS-SECTIONS OF STEEL INGOTS, SHOWING BLOW-HOLES.

BLOWHOLES IN STEEL INGOTS.

We reproduce herewith some interesting photographs of steel ingot sections which show the remarkable extent to which blowholes are sometimes found in such ingots.

As is pretty well known, blowholes are particularly objectionable in steel used for locomotive fireboxes, and some time ago a well-known locomotive manufacturing firm refused to accept basic steel plates for fireboxes on the ground that blowholes would be more apt to be found in such steel. To test the matter thoroughly, however, ingots were ordered from a number of different manufacturers, and a section was made of each through the center. These sections were etched and photographed, and some of these photographs are here reproduced.

As a result of the test, the specification was amended to permit the use of basic steel. The conclusion was reached that the extent of segregation and the presence of blowholes depended on the shape and size of the ingot, and the manner in which the steel was poured, as well as the temperature of pouring.

SOME FROST AND ADHESION TESTS OF CEMENT MIXTURES.

In constructing the water-power plant at Chaudiere Falls, Quebec, very thorough tests were made of the cements and concretes used in the various buildings and structures. Among these tests there were a number of unusual character, to which the name of special tests was given. These special tests, with others of ordinary character, are fully described in a paper by Mr. James S. Costigan read before the Canadian Society of Civil Engineers; and we abstract the following account of them:

The following special tests were made besides the regu-

lar ones called for by specifications, but had no bearing as regards the acceptance of the cements:

LOT I.—Four briquettes were made by filling molds with water, and then shoveling in dry cement with a small spatula, without ramming. The briquettes were placed in water when 24 hours old and were taken from the water when test was due and broken immediately—two at 7 days old and two at 28 days old: the results were: 7 days old, 222 and 214 lbs. per sq. in.; 28 days old, 445 and 437 lbs. per sq. in., tensile strength.

LOT II.—Four briquettes were made by filling molds with water and sifting in cement without ramming. They were placed in water when 24 hours old. One of the briquettes scaled off slightly after being in the water for 24 hours. Two briquettes were broken when taken from water after 7 days, and two at 28 days, and showed a tensile strength per square inch, as follows: 7 days old, 132 and 232, 212 lbs., and at 28 days old, 257, 254 lbs. per sq. in.

LOT III.—Four briquettes were made by filling molds with dry cement and pouring in all the water they would absorb but without tamping. When treated similar to lot II, the results at 7 days old were 232, 212 lbs., and at 28 days old 257, 254 lbs. per sq. in. tensile strength.

LOT IV.—Four briquettes were made by mixing cement with 20% of water and tamping into molds with a 1-lb. nail hammer. When 24 hours old they were placed in water until ready for testing. Two were tested when 7 days old and showed a tensile strength of 722 and 738 lbs., and two at 28 days old showed 707 and 747 lbs. per sq. in.

LOT V.—Four briquettes were made by mixing cement with 20% of water and placing in molds without any tamping whatever. When 24 hours old, they were placed in water until ready for testing. The results of this test were very poor; at 7 days old they broke at 28 and 32 lbs. per sq. in., and at 28 days old at 41 and 47 lbs. per. sq. in.

LOT VI.—Four briquettes were made by mixing the cement very wet (about 30% water), and placing in molds without ramming, then letting them stand with a pressure of about 3 lbs. per sq. in. for 24 hours. They were then submerged in water until tested. The results at 7 days old were 333 and 355, and at 28 days old, 613 and 688 lbs. per sq. in. tensile strength.

FROST TESTS.

In the following lots two briquettes were made of each by mixing cement with 20% of water, and placing in molds under pressure of 20 lbs. per sq. in. When 24 hours old they were all placed in water and allowed to remain there until they were 7 days old, with the exception of 24 hours during this period (as noted opposite each lot), when they were exposed to the action of frost for the length of time denoted. They were all tested in tension at the end of 7 days, as follows:

LOT VII.—Frozen for 24 hours after they were 24 hours old, then thawed out and put in water until 7 days old, when they broke in tension under 476 and 590 lbs. per sq. in. respectively.

LOT VIII.—Frozen for 48 hours after they were 48 hours old and then thawed out and put back in water until 7 days old, then tested with these results 505 and 490 lbs. per sq. in. in tension.

LOT IX.—Frozen for 24 hours after they were 3 days old, and then thawed out and placed in water until 7 days old; results of tension test 380 and 460 lbs. per sq. in.

LOT X.—Frozen for 24 hours after they were 4 days old, and then thawed out and placed in water until 7 days old, results being 485 and 487 lbs. per sq. in.

LOT XI.—Frozen for 24 hours after they were 5 days old, then thawed out and placed in water for the remaining day, then broken under load of 530 and 410 lbs. per sq. in.

LOT XII.—Frozen for 24 hours after they were 6 days old, and then thawed out and tested; these broke at 465 and 475 lbs. per sq. in.

In lots XIII., XIV., XV., XVI., XVII., two briquettes were made of each by mixing cement with 20% of water, and placing in molds under pressure of 20 lbs. per sq. in. When 24 hours old they were all placed in water. The subsequent treatment of each lot was as follows:

LOT XIII.—Was frozen in water when 28 hours old, and thawed out when 7 days old by exposing to a temperature of 120° F., and then broken in the machine, showing a tensile strength of 454 and 416 lbs. per sq. in.

LOT XIV.—Was frozen in water when 48 hours old, and thawed out when 7 days old by exposing to a temperature of 120° F., and then tested, the results being 448 and 417 lbs. per sq. in.

LOT XV.—Was frozen in water when 3 days old, and thawed out when 7 days old, by exposing to 120° F., and tested, the tensile strength being 460 and 405 lbs. per sq. in.

LOT XVI.—Was frozen in water when 4 days old and thawed out when 7 days old by exposing to a temperature of 120° F., and then tested, the results being 474 and 486 lbs. per sq. in.

LOT XVII.—Was kept in the water at a temperature of 60° F. until 7 days old, and then tested, and showed a tensile strength of 590 and 492 lbs. per sq. in.

When the briquettes in Lots XIII., XIX., XV., XVI., were frozen, the temperature ranged between + 32° to — 14° F.

LOT XVIII.—Six briquettes were made with 20% of water molded under a pressure of 20 lbs. per sq. in. When 24 hours old they were exposed to the weather and allowed to freeze, and kept frozen until 7 days old. They were not immersed in water at all, but were thawed out by exposing to heat for about 45 mins. No flaking or chipping of briquettes whatever occurred. The results, when tested at seven days old were, 342, 315, 341, 340, 353, 376 lbs. per sq. in.

LOT XIX.—Was made similar to Lot XVIII., and was immersed in water when 24 hours old, and taken therefrom when 3 days old, exposed to weather until 28 days old. The results of 28 days test being 297, 356, 268, 351, 285, 406 lbs. per sq. in.

LOT XX.—Five briquettes made same as Lot XVIII., and exposed to the weather when 6 hours old, not placed in water at all, thawed out before testing when 7 days old. The loads were 212, 200, 235, 283, 391 lbs. per sq. in. The cement on these briquettes was chipped or flaked off on both sides and edges when exposed to heat—about 1-32 of an inch from each face—this would reduce the sectional area somewhat. The above are the actual loads under which briquettes were broken.

LOT XXI.—Six briquettes made similar to Lot XVIII. and exposed to the weather when 12 hours old, and allowed to freeze. They were left exposed until 28 days old, the range of temperature being from — 20 to + 35° F., as per chart. The briquettes broke under the following loads when 28 days old, 327, 322, 300, 317, 303, 247 lbs. per sq. in.

ADHESION TESTS.

As some quantities of steel framing for racks, stop log checks, etc., had to be built into the concrete of the bulkhead, the concrete would act as a protection for the steel embedded in it to a certain extent, and as the expansion of concrete and steel are nearly the same, it was reckoned they would stand without cracking when once well joined together, but it was desired to protect the exposed portion of the steel work from oxidation if possible with some kind of paint or composition to which the mortar of the concrete would adhere, so a few experiments were made to determine whether red oxide or asphaltum paint would be most adhesive in this position and also to determine whether the clean dry steel or rusty plates would hold to the cement better than the painted surfaces.

The method adopted was to place a piece of ⅛-in. steel plate 1 in. square in the center of the briquette molds at right angles to the flat surfaces of same, and the cement which was mixed with 20% of water in the usual manner (by hand) was filled into the mold on both sides of the steel plate and rammed against same, care being exercised in this operation to keep the plates central.

LOT XXII.—The plates used in this lot were exposed to the weather for a period of 14 days and were thoroughly rusted, but not corroded, before being placed in the molds. The briquettes were immersed in water when 24 hours old, then removed after 36 hours, and left in a damp place until 7 days old, when they were broken in the testing machine. Only two briquettes were successfully molded of this lot, and when tested they broke at 60 and 70 lbs. per sq. in. respectively, the fracture taking place at the junction of the steel plate and cement.

LOT XXIII.—The 1 × 1 × ⅛-in. steel plates in this lot were clean and smooth when placed in the molds, and cement tamped in on both sides of same. The briquettes were immersed in water when 26 hours old and left for 24 hours, after which they were removed and placed as to be damp until 7 days old, when they were tested with these results, 37, 15, 40 lbs. per sq. in. All briquettes broke at the plate, the same remaining attached to that part of briquette in the lower jaw of machine.

LOT XXIV.—The 1 × 1 × ⅛-in. steel plates used in this test were thoroughly cleaned, then heated and while hot were painted with asphaltum paint. The plates were allowed to stand for 12 days, then placed in briquette molds and cement mixed in usual manner and placed on each side of plate in mold. The briquettes were taken from molds when 10 hours old and placed in water. After 24 hours in the water they were taken out and placed in a damp place until tested, when 7 days old. The results were: 30, 35, 22, 60 lbs. per sq. in. In the first three tests the asphalt pulled off the plate; in the fourth case it adhered to plate in many places.

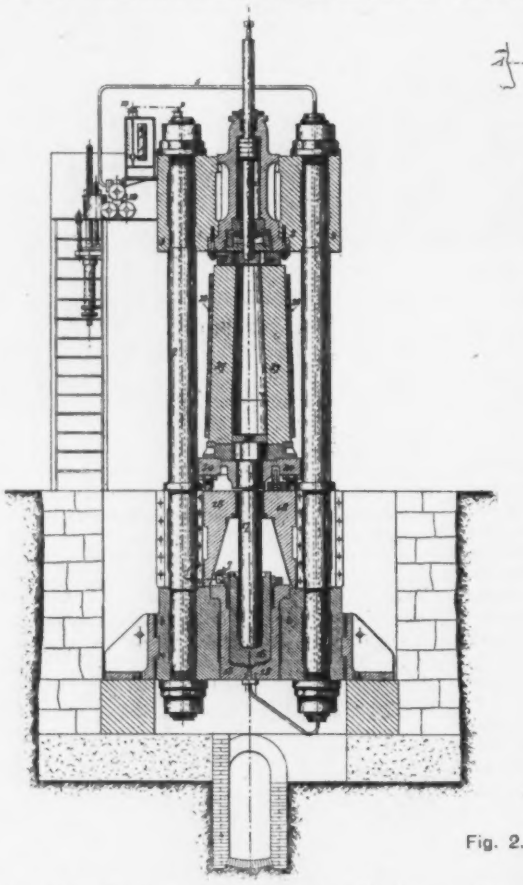


Fig. 1. Hydraulic Press for Compressing Steel Ingots by Wire Drawing at St. Etienne Works, France.

Two attempts were made to make briquettes with steel plates in them, that had been painted with two coats of red oxide, the first coat being applied 12 days before the second, and they were placed in molds 10 days after the second coat of paint was applied, but all briquettes broke at plate when being removed from the molds, in the usual manner. It was found that the cement would not adhere at all to the steel when painted with this pigment.

It is regretted that more tests were not made in this direction, as there are several other paints that might have been experimented upon, and as steel work is being used more and more in connection with concrete dams, bulkheads and other structures of this nature more or less exposed to atmospheric changes, it is to be hoped that in the near future complete data on this subject will be forthcoming.

COMPRESSING STEEL INGOTS BY WIRE DRAWING IN THE INGOT MOLD.

The problem of procuring solidity in steel ingots is one that has long attracted the attention of inventors and engineers. As is well known, in all steel ingots a tendency exists toward the formation of a cavity at the center, technically known as piping, and gas bubbles entrained in the molten metal at the moment of cooling give rise to blowholes. Liquation, or the separation from the molten mass of portions which contain higher or lower percentages of the metalloids, is another source of trouble. Thus the carbon tends to rise toward the top of the ingot, and if solidification is delayed by the use of a mold lined with non-conducting material, the top of the ingot will have a considerably higher percentage of carbon than the bottom.

To diminish or prevent the formation of blowholes and piping, many inventors have attempted to apply pressure to the ingot while cooling. The best known system is of course that of Sir Joseph Whitworth, in which the top of the ingot after casting is subjected to heavy hydraulic pressure. The Whitworth process has never come into extensive use, however; and one reason, as pointed out by Prof. Howe in his "Metallurgy of Steel," is that in applying pressure to the top of the ingot the outer shell of the ingot resists the pressure like a hollow column. What is wanted is to drive the sides of the ingot toward the center, and lateral compression of ingots has been proposed and actually carried out by some American experimenters.

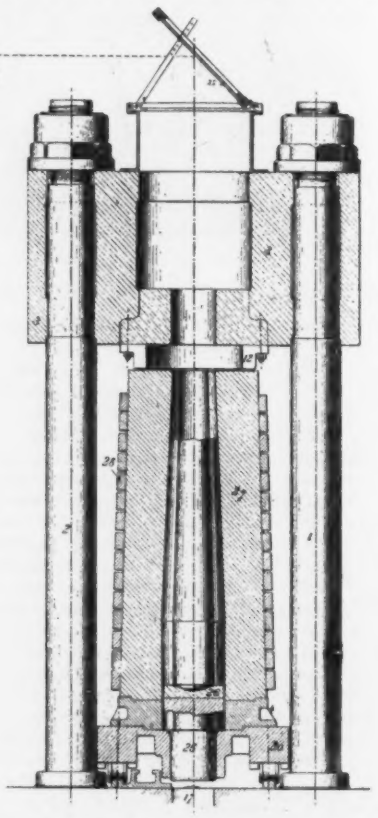


Fig. 2. Arrangement of Mirrors for Watching Rate of Compression of Steel Ingot.

At the recent meeting of the Iron & Steel Institute at Duesseldorf there was described a new method of compressing steel ingots by a so-called

wire-drawing process. The ingot mold is made slightly tapering, being largest at the bottom, and is heavily hooped to sustain internal pressure. After the mold is filled with molten metal and solidification has begun the mold is run upon a hydraulic press and a plunger is brought to bear against the bottom of the ingot, forcing it upward, and compressing it by reason of the tapering walls of the ingot mold.

This process has been adopted at the steel works at St. Etienne, France, where a process of ingot compression similar to Whitworth's was in use many years ago. The paper read before the Iron & Steel Institute was by Mr. A. Harmet, of the St. Etienne works, and he stated that the process is also to be introduced at the Parkhead Steel Works in Glasgow, Scotland, where armor-plate ingots weighing 30 to 40 tons will be treated.

At St. Etienne the plant for compressing ingots comprises five presses, three of 1,200 tons capacity each, suitable for 4 to 5-ton ingots, one small press and one press which deals with four large ingots at once. The apparatus is described by the author as follows:

Two tie-bolts of forged steel (1 and 2) hold apart an upper and lower cross-piece (3 and 4). These tie-bolts are hollow, and the central hole of the one serves as a pipe to conduct the water to the press, this being led from the distribution valve through the passage 5 and again from the tie-bolt to the hydraulic cylinder by the lower passage 6. Through the central opening in the other tie-bolt are led two small cords having their lower ends attached to the ram of the press. Thence they pass up through the hollow bolt over two pulleys, 8 and 9. From the second pulley onwards the ropes separate, one being led over the pulley 10 to an indicator within sight of the operator, where it actuates a pointer which traces the curve indicating the speed of ascent of the piston. The other is carried to the accumulator and governs the regulating valve, stopping the press automatically if the operator is inattentive or passes the desired point.

The cast-iron cross-piece 3 carries attached to it a plate 12, which is vertically adjustable, and serves as an abutment against which the top of the mold rests during compression. The stripping cylinder 13, with a double-acting piston, is also carried on the upper cross-piece. The lower cast-iron cross-piece 4 has attached to it, first the two supports 14, which serve to strengthen the whole arrangement; secondly, the forged steel cylinder 15 and the actual piston 16, which carries the ram 17 extending upwards, both of these latter being also of forged steel. The intermediate cast-iron cross-piece 18 performs the service of guide to the ram 17. The operator is accommodated on the platform P, within reach of the starting valve 19 and the indicator 11. The quantity of water required is very little, and can be supplied by an accumulator of small size, which regulates the pressure and controls the small pumps which feed it.

The compression is effected between the ram 17 and the plate of abutment 12 attached to the upper cross-piece. The steel which has to undergo compression is contained within its mold 27, and is brought up to the press on a small trolley 20, a track being provided for this purpose.

CAR FOR INGOT MOLD.—The car 20 is of cast iron, and the axles of the wheels are of extra strength to withstand the shock of the stripper which is added to the weight of the ingot and mold. The car is moved by means of a pawl carried on a rock 23, which engages with the ribs cast underneath the body of the car. At one end is attached an eye-piece in which is inserted a conical pin for stopping the car when immediately beneath the press, and for fixing it immovably in that position, so that the center line of the press corresponds exactly with that of the mold, the ingot, and the bottom of the mold. This latter (25) acts as a movable plunger within the mold during compression. The under side is of a special form and between it and the circumferential portion of the upper surface of the ram 17 is allowed a play of 1 mm. If during its passage upwards into the mold it should deviate from its axis and tilt to one side—an unlikely event, but the occurrence of which must be provided against—the ram of the press, pushing then at one side only, will guide it back to the perpendicular course. It is well to protect the upper surface of the bottom against the action of the steel during pouring by a cast-iron disk (26), 30 to 60 mm. in thickness, which may be easily changed when worn out.

INGOT MOLDS.—The ingot mold is formed in the first place of cast-iron casing consisting either of one or several parts. This is the mold proper, the interior near the base being cylindrical in form, that is with vertical walls. Then towards the top, beginning at the line xy, the form becomes conical with a taper of 1 in 30. Secondly, it consists of one or even two series of hoops (28) of cast and rolled steel, which encircle the mold and hold the several sections firmly together.

When the car with the mold containing the liquid steel is brought beneath the press, the whole arrangement presents the appearance shown in Fig. 2. It then remains to compress the ingot, crushing it together, and wire-drawing it, meantime taking the precautions necessary, first for keeping the ingot from flowing over and preventing the formation of pipe, and secondly for avoiding the excessive spurting of the hot metal out of the mold, which causes a waste and is due to too great a speed in performing the operation. The contraction of the ingot must then be followed up, and the rate of this should even be slightly exceeded in order to compress the core of the ingot, but care must be exercised not to allow the metal to flow over the edge of the outer shell. As regards the upward speed of advance which is most suitable to give to the piston of the press, this must vary according to the rate of contraction.

After preliminary trials it was found that the conduct of the operation could be simplified. Instead of taking an approximate curve for the rate of compression and following it while controlling the press by hand and then dividing the ingot to see if it is sound, it is much more simple to remove the stripping cylinder and substitute a mirror (35) at an agle of 45°, which reflects the surface of the ingot within the mold during the whole time that it is under compression (see Fig. 2). By watching the mirror it is possible to control the press with perfect ease and to regulate its speed, keeping the ingot full of metal to the brim, with just a tendency to overflow. From a first trial is obtained in this manner an absolutely sound ingot. The top is not quite so smooth as if the piston of the stripper had rested on it, and the stripping must be effected elsewhere, but this is a matter of no great difficulty. During compression, with the aid of the mirror, the pencil of the indicator has traced on the white paper a curve of speed of the press, and for the succeeding operations with the same mold it is only necessary to follow the same curve.

There are two phases in the cooling of a cast-steel ingot —(1) that which occurs from the time of casting till solidification is complete, (2) that which begins from the moment of solidification till the ingot is cold. During the first phase the steel undergoes the greater part of its contraction, giving rise to cavities or pipe if left undisturbed. During the second phase the steel continues to contract slowly until cold, developing internal stresses if left un-

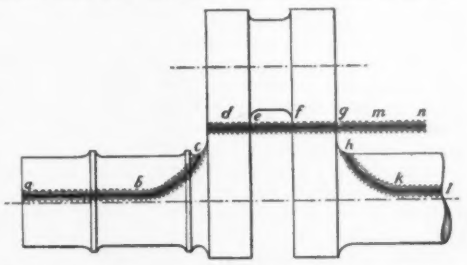


Fig. 3. Low-Pressure Crank Axle of Locomotive of the Western Ry. of France, Showing Piping.

disturbed. Compression by wire-drawing may be applied during the first phase only to prevent the formation of cavities, in dealing with comparatively large ingots. It may also be applied during the second phase in order to diminish the stresses due to the final cooling, in dealing with comparatively small ingots containing more energy.

In most cases it is advantageous to perform compression during the first phase only, then to strip the ingots while still hot and plunge them in the pits previous to sending them for further treatment in the mills or forging presses.

PRACTICAL RESULTS OBTAINED BY COMPRESSION BY WIRE DRAWING.

In an existing works of which the various buildings and mechanical appliances are well arranged, compression by wire drawing increases the productive capacity by 25%.

In constructing new works, for the manufacture of armor plate, for instance, the adoption of compression enables the same weight of finished products to be turned out, but with a reduction in the mechanical equipment, furnaces, and plant of 25% as compared with an ordinary works of the same capacity of output.

When the steel is not compressed it is necessary to cut off from the upper part of the ingot about 30 to 40% of the length, in order to reach the sound portion towards the base, which appears to the naked eye almost compact. The advisability of removing a still greater waste piece is revealed by the aid of a lens or the microscope.

When steel is compressed by wire drawing it is sufficient if 4% be cropped off the top of the ingot. A general examination of sections of compressed and uncompressed ingots cast in iron molds without refractory lining, at the St. Etienne works proves conclusively that the waste at the head of the ingot averages 25% less with the compressed ingots. When ingots are cast in refractory-lined molds, the waste would be slightly less, but for the lining to have any effect it must extend some distance below the top of the ingot, and consequently that portion covered with sand must afterwards be removed, which causes considerable wastage. Besides this the lining is expensive, and tends to aggravate liquation.

It may next be shown how the influence of compression affects the body of the metal during solidification, and how it finally renders the metal absolutely sound. Photographs 36 to 41 (not reproduced) represent sections through the vertical centers of small ingots of about 120 kg., compressed during five, six, seven, eight, nine, and ten minutes respectively, which were then left to contract freely.

After five or six minutes the metal is still liquid, or at least pasty about the center at the time the action of the press was interrupted. The subsequent contraction took place, to the injury of the part not yet solidified, and it yielded to the tension, leaving cavities which however diminish in size as the time more nearly approximates to that necessary for solidification. At the end of eight minutes solidification is complete, and this period corresponds, for the ingot of 120 kg., to what was before termed the first phase of cooling. If this were taken to the mills immediately on leaving the press, and there treated mechanically, it would give a perfect metal. If, on the contrary, it is allowed to cool after these eight minutes of compression, the ingot remains these eight minutes of compression, the ingot remains solid, since the metal is no longer mobile. Cavities can no longer be formed, but the metal is cracked by the shrinkage subsequent to compression, and the cracks are easily discernible in ingot No. 39. The lowest limit for the compression of ingots of 120 kg. is therefore eight minutes, the compression leaving them free at the moment that solidification is complete, and while the metal is still weak. At the end of nine minutes no defect is apparent to the naked eye, notwithstanding the shrinkage which continued after compressing. If in regular practice, in the manufacture of crucible steels, for instance, the ingots were allowed to cool to the temperature of the atmosphere, a compression of nine minutes would then be found to be almost sufficient.

Still, in order not to risk coming too near the limit, a compression of 10 minutes' duration ought to be allowed for ingots of 120 kg. with molds of low-cooling power such as were employed in these tests. Absolute soundness of metal would then be assured; but even then it would be preferable to work it immediately on leaving the press and not allow it to cool. A compression of eight minutes' duration is however sufficient if the ingot while hot is stripped and sent to the rolling mills. In photograph 41 is shown an ingot of 80 kg. cooled after a compression of eight minutes. For crucible steel the time necessary for compression is less than for open-hearth steel, since the pouring is much slower. The influence of compression by wire drawing on the cooling is noteworthy, as this takes place almost evenly from top to bottom, the head cooling about as rapidly as the base, a condition which favors the chemical homogeneity of the metal.

The compactness resulting from compression extends throughout the whole mass, and gives a sound metal thoroughly homogeneous in the very center of the ingot.

A compact metal, free from defects in the very core, is undeniably the best for every kind of manufacture, since forging or rolling always has a tendency to strain the core of the metal, a tendency which is aggravated by the defects already existing. Thus all armor plates show about the center of their thickness a plane of fatigue, which becomes a plane of rupture if the rough ingots show central cavities developed during rolling. The use of these compact ingots for the forging of axles or crank shafts is more important still.

The crank shaft is, of all the component parts of a locomotive, perhaps the most delicate and most difficult to guarantee. The cause of this inferiority is twofold: first, the great fatigue of the metal, to which for lack of space it is almost impossible to give a rational form; secondly, the existence of weak spots in the material exactly at those points where the greatest stresses occur. In the forging of it, however, only the quality of the product enters into consideration, and the second cause of inferiority is therefore at present the only matter for concern.

In all ingot steel, cast freely without compression, the core exhibits from top to bottom (apart from the pipe) a defective material full of porosities due to contraction. Etching with acid brings out at once the defects which are not directly visible. On examining subsequently the change of shape during forging to try and trace what becomes of this defective core among the mass forming the crank shaft, it will be found to crop out on the surface exactly at the points where the working strain is greatest. In a shaft of which the two webs are forged direct to an angle of 90°, the core of the ingot follows approximately the line a, b, c, d, e, f, g, h, k, l (see Fig. 3).

In a shaft of which the two webs are forged in line and are afterwards bent to 90°, the core of the ingot follows approximately the line a, b, c, d, e, f, g, m, n. The first method of forging is then apparently the most defective, as it brings out the core of the ingot to the surface about the points c, d, e, f, g, h.

An examination made of numerous fractures of crank shafts shows that such fractures generally start from the points c, e, f, h, and everything tends to prove that they are attributable to the weakness of the metal at these points. Since the compression of steel by wire drawing obviates the defects which occur in the core of ingots, it is to be hoped that crank shafts of compressed steel will offer more resistance than those from uncompressed metal under the same conditions of shape and stress.

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The proper color for elevated railway structures in the public streets is not very easy to determine, and the color used in each case depends largely upon whether it is selected simply as a protective covering or with some regard to its aesthetic effect. The railway company will naturally prefer a dark color which will show dirt and discoloration as little as possible, so that the work of repainting will be required only at long intervals. The persons using the streets, however, and particularly the property-owners and the keepers of first-class stores, will much prefer a light color, which will tend to neutralize the darkening effect of the structure in obstructing the light. In cities reasonably free from smoke such light colors may well be used, and the railways companies will probably offer little objection to them; but in cities which suffer from the soft coal smoke nuisance, it remains to be seen how far their use will be advisable, since they are likely to be so soon discolored, and then be, perhaps, more unsightly than a less pleasing color which will be more permanent. An interesting example of the color question is afforded by the elevated loop railway in Chicago, which is built entirely through the streets. When first built, some four or five years ago, the structure was painted a dark smoky grey, the effect of which was to make the streets appear somewhat dark and gloomy, but which showed little change from exposure to the smoke and dirt of that smoky and dirty city. At the present time the entire structure is being repainted, with two exactly opposite color schemes. On Wabash Ave. (which has a number of handsome buildings and high-class stores) and Van Buren St., a light yellowish-white or yellowish-grey color is used, which very quickly weathers almost to the shade of the buff Indiana sandstone. It has a very pleasing appearance, and its effect in lightening up the streets is quite remarkable. This is specially noticeable on Van Buren St., which is narrow and has mainly old dingy buildings. How long it will be before the color is spoiled by smoke and dirt, so as to be (perhaps) more objectionable than a darker color which will not show the discoloration, must be determined by experience. On the Fifth Ave. side of the loop (where the buildings are old and dark, and occupied by wholesale and commission houses, second rate stores, etc.), the structure is being painted with a jet black graphite paint. The effect is distinctly bad, as the color stands out very strikingly against the dingy surroundings, with which the original dull grey harmonized to some extent. The black is therefore more obtrusive than the grey, and makes the street look even darker than before. The same paint is used for the stations, stairways, and all parts of the structure and has a most gloomy and depressing effect. Two of the four Chicago elevated railways use the dark smoky grey, already referred to, which is a neutral and inconspicuous color. A third uses a "rust red" color, and the fourth (which is built in the alleys instead of in the streets) uses a pale yellow.

An example of the extra cost of contractors' time guarantees was afforded recently at Atlantic City, N. J. The successful bidder for laying a 20-in. cast-iron submerged water main, with ball joints, bid $7.90 per lin. ft. for the work without, and $9.25 with a five-year guarantee. The city wisely decided not to pay $1.35 per lin. ft. for a guarantee which would be of doubtful value at best.

By the introduction of systematic methods of book-keeping, cost-keeping, time-keeping, etc., in machine shops, foundries and other manufacturing establishments, a great reduction has been made in cost of production. The adoption of similar methods in construction works carried on outdoors over large areas is rather uncommon. In former times, when work was done on a smaller scale than now, very simple systems in the way of records sufficed, and anything more was condemned as red tape. Even now a great deal of work is carried on in a similar way; but on works of large size the value of detail records is more and more appreciated.

In another column of this issue is described the methods employed in keeping a record of the work of laying a large system of gas mains near Boston, and samples of the records kept are given which should be useful to any engineer engaged on a similar task.

We venture to call especial attention to the very complete record made of the location of the pipe underground, and of all special fittings laid. The value of such complete records is too well known to need proof; but it is sometimes the case, even at the present day, that valuable and costly work is buried in a street and in the rush of construction an inadequate record is made of its location.

THE NEW YORK CANAL QUESTION AGAIN.

Three weeks ago we discussed in this place the revival of the project for a 1,000-ton barge canal, to be built by the State of New York, from the Lakes to the Hudson. We then urged that the route via Oswego and Lake Ontario be selected for such a canal, and not the route along the present line of the Erie Canal, from Syracuse westward.

We print on another page of this issue a contribution by Major T. W. Symons, Corps of Engineers, U. S. A., arguing against the Ontario route and in favor of the inland route. We hardly need say to our readers that Major Symon's opinions in this matter are entitled to great weight. He has made a special study of the problem of water transportation from the Lakes to the seaboard for half-a-dozen years. His report to the Chief of Engineers in 1897 on this subject was a most able contribution to engineering literature. He later served as a member of Governor Roosevelt's Canal Advisory Commission of 1899, which recommended the construction of a 1,000-ton barge canal, for which surveys were made in 1900. He was also a member of the Board of Advisory Engineers organized in connection with the barge canal surveys of 1900. Further than this, Major Symons, if we mistake not, is really the originator of the barge canal project. It was in his 1897 report that the large barge canal was first advocated as the most economical waterway from the Lakes to the seaboard. The Roosevelt Advisory Commission two years later practically adopted this plan, only reducing the size of the vessels to be accommodated to 1,000 tons in place of the 1,500 tons originally proposed by Major Symons.

Certainly, then, Major Symons' views on this subject are deserving of careful consideration, and we take pleasure in giving space to them, notwithstanding the fact that they are diametrically opposed to the opinion which we expressed and still hold.

In considering Major Symons' brief against the Ontario route, attention is attracted particularly by his conclusion, in which he declares with emphasis that a barge canal built by the Ontario route would be a failure. If this is the case, why was it not stated in the report of the State Engineer upon the canal surveys? This report was prepared in consultation with a board of eminent engineers, of which Major Symons was a member. The respective advantages of the Ontario and inland routes were described in the report; but especial care was taken to refrain from recommending one over the other. The plain inference to be drawn from the report was that either route was available for the construction of a successful barge canal. If the Ontario route is so hopeless a proposition as Major Symons thinks, the engineers should have made a definite report against it. As they did not do so, it seems fair to conclude at least that a difference of opinion existed in the board as to the commercial advantages of the rival routes.

We call attention to this, not at all by way of criticism, but to illustrate what we believe to be the fact: that the question which route is the preferable is one on which experts are by no means agreed. Nor is this at all strange. We are taking a look into the future—estimating what business conditions will obtain half-a-dozen years hence, and what type of water transportation will be most efficient in a waterway now nonexistent, and the like of which has never been made.

To illustrate: Major Symons has frequently set forth in his various reports the proposition that for most economical carriage different types of vessel should be employed on the canal, the lake and the ocean. This is all true in the abstract, and yet the raising of transfer rates by elevator combinations at Buffalo or New York might make a type of vessel which could go from the upper Lakes to European ports without breaking bulk the preferable vessel to use. Or again, Major Symons has laid much emphasis on the great difference in the cost of a canal barge and a lake or ocean steamer. Yet at a time when ocean steamers or lake steamers are tied up for lack of other business, or when a great rush of traffic brings every available vessel into service, a canal, if one of sufficient size were available, might be used by great numbers of the larger vessels.

It is not our purpose to discuss seriatim the points raised by Major Symons. Most of them were gone over in the editorial in our issue of Sept. 11, and others are answered—or at least contrary evidence is given—in a letter from Mr. R. A. Downey, of Oswego, published in our department of "Letters to the Editor" this week. Instead of discussing further these controverted questions, we want to present the matter from quite a different point of view:

The cost of the inland route favored by Major Symons is $70,323,000, and the cost of the Ontario route is a little less than $50,000,000.* Manifestly, the State ought not to spend this additional $20,000,000 if $50,000,000 will accomplish practically the same results. Whether it will or not, is a matter on which opinions differ, and what we wish to suggest is, *why not try the cheaper route first?*

One particular reason why the less costly route

*These figures are taken from the careful estimates made in connection with the barge canal survey under direction of the State Engineer of New York in 1900.

ought to be tried first is that the larger the cost of the project adopted, the smaller is the chance that the voters of the State can be induced to favor it. If the friends of the barge canal project really desire its success they ought to deeply ponder this fact.

Turning to the report on the barge canal surveys, we find that the State can build a waterway from the Hudson to Lake Ontario, at Oswego, to accommodate 1,000-ton barges, for $40,300,000, in round numbers. If the State would do this, then barges could load at Buffalo, pass over to Port Colborne, descend the Welland Canal, and sail eastward to Oswego, and thence through the canal to the Hudson, and the whole trip would take no longer time than would be required for passage through the $70,000,000 inland route, which Major Symons favors. If desired, the State could assume the payment of the Welland Canal tolls in order to give this route an entirely fair trial. If it were found by this trial that the route was a success, the construction of the 1,000-ton barge canal from Erie to Ontario on the American side could then be proceeded with.

Let us suppose, however, that Major Symons is right in his opinion that vessels adapted to navigate both the canal and Lake Ontario cannot be made a commercial success; and that this is proved by actual experience when the canal to Lake Ontario is completed and opened to navigation. Parenthetically we may remark that it is doubtful if it can be proved in any other way than by actual test.

If this situation develops, so that the interior route is then found to be essential to the success of the canal, the State can simply proceed to construct the line from Syracuse to Buffalo, and it would then have the canal which Major Symons advocates and would have spent nothing additional save the cost of building a 1,000-ton barge canal in place of the present Oswego Canal (about $5,000,000, according to the engineer's estimates). This cannot be considered a loss, either, for if the 1,000-ton barge canal can do all that is claimed for it, the small additional cost of the branch to Lake Ontario would be money well expended. In fact, the canal plank adopted by the Republican State convention last week calls for the improvement of both the Erie and the Oswego canals on the same lines.

To put the matter in another way; the State is asked to spend $70,000,000 to build a canal across it from east to west, and $30,000,000 of that sum is to be spent on the route from Syracuse westward, parallel and not far from Lake Ontario. Why not postpone building this part of the route until a trial can be made of the waterway which Nature has provided?

And now we want to call attention to another alternative open to the State, and one which we believe is still more preferable to the $70,000,000 barge canal on the interior route, advocated by Major Symons. Careful reading of his paper in another column will show that his objection to the Ontario route is that canal barges would have to navigate the lake. Now let us meet this objection by giving the Lake vessels access to Lake Ontario; make Oswego their terminus instead of Buffalo, and let the 1,000-ton canal barges take on their load there.

But, it will be said, is this practicable within reasonable limits of cost? It is perfectly practicable. No one need guess on this matter now, as was necessary a few years ago. At an expense of nearly half a million dollars the United States has made complete surveys and estimates for a waterway 21 ft. deep, sufficient to accommodate any vessel on the Lakes, and probably three-fourths of the merchant shipping of the ocean, the waterway to extend from Lake Erie via Lake Ontario to tidewater at New York. The portion of this survey to which we would now direct attention is that for a canal from Lake Erie to Lake Ontario. Its estimated cost is $42,000,000 in round figures. As we saw above, the cost of a 1,000-ton barge canal from Lake Ontario to the Hudson is $40,000,000, making $82,000,000 for the whole work which we now propose. In other words, for only $12,000,000 more than the estimated cost of a barge canal by the interior route the State can not only secure the 1,000-ton barge canal from the Lakes to tidewater, but it can give the entire lake fleet access to the ports of Lake Ontario. The benefits this would bestow on Ogdensburg, Oswego, and the other ports on the south shore of Lake Ontario, and, indeed, upon the entire northern part of the State of New York, are too obvious to call for proof. If the State can afford $70,000,000 for the inland barge canal, it can well afford $12,000,000 more to have a Niagara ship canal besides.

And now we want to call attention to still another alternative. We do not believe it is even necessary for New York to expend this $12,000,000 additional to secure this great benefit. If she would offer to pay half the cost of a Niagara ship canal, there can be no doubt that Congress would undertake to bear the remaining half, particularly if New York couple with it an agreement to build a 1,000-ton barge canal from Lake Ontario to tidewater. This would make the total expense to New York only $61,000,000—or $9,000,000 less than the cost of the inland canal route. We will even go farther and say that if New York will build the barge canal alone, Congress would almost certainly vote the entire amount required to build the Niagara ship canal.

The fact is that the matter of cheap transportation to the seaboard is more important to the states of the Northwest than it is to New York. Representatives from all these states would surely unite with New York, New Jersey and New England in favoring such an enterprise, and such a combination includes much more than half the membership of the House of Representatives. Here is the apportionment of representatives to the several states which would be sure to favor such a measure:

New York	37	Michigan	12
New Jersey	10	Minnesota	9
Pennsylvania	32	Iowa	11
New England	29	Dakota	4
Ohio	21		
Indiana	13	Total	214
Illinois	25	Total membership of House	386
Wisconsin	11		

But we need not stop here. If New York is willing to spend from $40,000,000 to $70,000,000 to build a canal 12 ft. deep across her territory, she ought to be willing to contribute an equal amount toward the construction of a canal 21 ft. deep from the Lakes to the seaboard, passing all the way across her territory; and if she would do that, there is every reason to believe that Congress would be willing to furnish the balance of the $200,000,000 estimated as necessary for this great work.

We are well aware that there is a general impression abroad that a ship canal from the Lakes to tidewater is an impossibility. It has even been said that if such a canal were built it would be used chiefly by barges, such as are proposed for use on the smaller waterway now proposed. This idea has grown largely out of the first plans for deep waterways from the Lakes eastward, which proposed a channel deep enough to take the largest ocean vessels. Such projects were indeed chimerical. It is *not* practicable—commercially speaking—to take such ocean vessels to the Lakes. It *is* practicable to bring the Lake vessels to the seaboard; and here is where they all would come during the winter season when the Lakes are closed to navigation, were a channel once provided.

We cannot take space at this time to draw the contrast in detail between the barge canal and the deep waterway proposition—the 12-ft. channel and the 21-ft. channel. We cannot refrain, however, from showing the contrast in speed of transit. The official estimates for the sailing time from Buffalo to the Hudson River are, by the barge canal, 4 days, 13 hours; by the deep waterway, 2 days and 4 hours. The commercial value of this increased rate of speed in enabling the waterway to compete effectively with rail lines can hardly be overestimated. Such a waterway could compete with the railway in moving the highest class of goods, and even in passenger traffic. The barge canal, on the other hand, is designed chiefly for the lowest class of bulk freights.

Finally, we may say that we do not at all expect that our suggestions will meet with approval from the chief promoters of the barge canal proposition. While many men among its adherents are working in entire good faith, for the public welfare, the most active promoters of the barge canal are those interested in the transfer at New York and Buffalo. They want the cost of transportation reduced so that a larger margin will be left for transfer tolls at each end of the canal route. Buffalo has been induced to give its support to the barge canal project only because it believed with Major Symons that the canal barges could not navigate the lake, and would have to take on their load at Buffalo. New York would oppose a ship canal for fear some vessel might sail past without stopping in its harbor. Yet both these cities, and especially the latter, are great enough and prosperous enough to look at the question from a broader standpoint. Nothing is better established than that it is a slow process to change established channels of trade. With Buffalo's railway connections, magnificent terminal facilities and vast extent of manufactures her future is sufficiently ensured. As for New York—for every ton of freight that would pass her doors without stopping, a dozen additional would be delivered at her wharves, were she made the terminus of a deep waterway from the Lakes.

We need hardly say to our readers that Engineering News has been extremely conservative in its treatment of waterway projects. We have presented many times evidence to show that the day of the artificial canal as a competitor of the railway is past. We favor the project for joining the Lakes to the Hudson because it is not a canal, in the usual meaning of that term, which is proposed, but a link to connect two great systems of water transportation which now carry a vast commerce. Its traffic, therefore, is assured, and its benefits would not be confined to any special locality or interest. Its construction by State or national funds would be fully justified, therefore, because of the wide range of territory and great population which would receive its benefits.

LETTERS TO THE EDITOR.

The Compensation of Engineers.—Continued.

Sir: G. P. H. made the mistake of his life when he went into engineering. He should have been a doctor. I have been an invalid for many years and know now why it is that doctors rapidly get rich. A few characteristic instances will suffice:

Case I. A doctor threatens to throw up the case if any other doctor is called into consultation.

Case II. A doctor being asked as to the nature of a medicine he prescribes successfully evades answering.

Case III. A patient at a sanitarium at a ruinous expense and obviously growing worse is coaxed and persuaded to stay.

It is my opinion that the character of the medical profession would be elevated instead of degraded by introducing competition among its members (using proper precautions as in first-class engineering work.) The fact of being obliged to guarantee some sort of a result showing plans and details, and giving bond, etc., as engineers do, would make them less reckless.

In conclusion I would say that I never have made any money out of engineering and "need the money" quite as badly as your correspondent. Yours truly,

L. C. H.

Defiance, O., Sept. 26, 1902.

Advantages of the Ontario Route for a Barge Canal.

Sir: Referring to your editorial in your issue of Sept. 11 pertaining to the New York Barge Canal project, we take the liberty of enclosing herewith an extract from a letter we wrote under date of June 18, 1902, bearing on this subject, which covers some points not included in your article. Yours truly,

R. A. Downey.

Oswego, N. Y., Sept. 20, 1902.

(The extract enclosed is as follows.—Ed.)

To counteract the increased cost for the suitable construction of 1,000-ton barges for Lake Ontario use, and the assumed consequent reduction in cargo capacity, there would be:

(1) The enormous saving in the cost of construction of the lake and canal route. (Estimated by the State Engineer of New York at $25,500,000.)

(2) The greatly reduced cost in the maintenance of such a route when built, as there would be only 67 miles of standard section and 113 bridges to operate and maintain as against 257 miles of standard section and 610 bridges on the more expensive line of the present Erie Canal.

(3) The distance by the Oicott-Oswego-Mohawk route is nine miles shorter, and with the open water would give a

saving of about 30 hours on each round trip between Albany and Buffalo.

(4) The Olcott-Oswego-Mohawk route is substantially a new line, and the work could be under construction almost continuously and finished within a comparatively short time, while on the line of the present Erie Canal most of the work would have to be done during the closed season of navigation, which, together with the much larger amount of work to be done, would greatly prolong the construction.

(5) While either route would care for all the traffic of the Niagara River, and Lake Erie lying within the State of New York equally well, the lake route would also give an equal benefit to the 310 miles of water front along Lake Ontario and the St. Lawrence River within the borders of

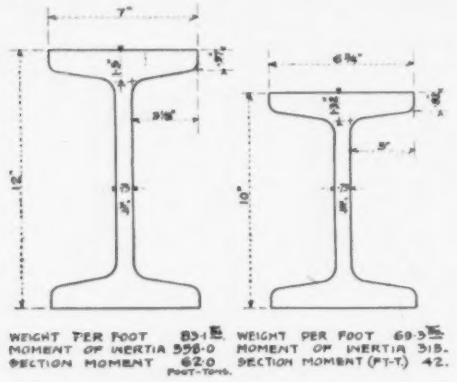

Fig. 1. Special Sections of 10-in. and 12-in. I-Beams for Use as Girders, Proposed by Mr. W. F. Scott.

this state; and would also no doubt open up to the Dominion of Canada an attractive route for its products to New York, and result in a large increase in the commerce of the state.

As to the matter of the insurance companies declining to accept the lake risk cargo, we think they must have had in mind risks by the ordinary Erie Canal boat, as the insurance companies now accept lake cargo risks by barges such as those operated by the Geo. Hall Co., and the O. C. & T. Co. from Lake Ontario ports to St. Lawrence River points, at regular rates.

It is already a well known fact that 250-ton canal boats are now being operated with little or no cargo loss on Lake Erie, which, on account of its shallowness, is more easily disturbed by the elements than Lake Ontario. And it is also an established fact that wooden barges, ranging in capacity from 300 to 1,000 tons, are successfully trading from Charlotte, Sodus Point, Fair Haven and Oswego to St. Lawrence River points, and very little if any loss due to storms has resulted during the past ten years. You will note from letters we are sending you under separate cover that a number of the most prominent and thoroughly practical vesselmen on the lakes express favorable opinions as to the feasibility of 1,000-ton barges being handled between Olcott and Oswego and with comparative safety. I believe that there is not a single experienced and practical vesselman, who is unprejudiced, who would not concur in these views.

Proposed New Sections of Ten-Inch and Twelve-Inch I-Beams for Use as Girders.*

Sir: The minimum weight "standard" sections of I-beams adopted by the American Association of Steel Manufacturers in January, 1896, and rolled by most of the steel mills in this country, are an efficient series of I-beams. They give a beam of comparatively high flexural strength per pound of metal, and they are ample in the web for resistance to buckling and longitudinal shearing along the neutral axis. The same cannot, however, be said of the "special" weights of I-beams which do not give the same economic results; they are not as scientifically designed as the "standard" sections, in fact, they in most cases were not designed at all; they "just growed." They are generally made on the same rolls as the "standard" sections by separating the rolls enough to admit the extra metal, and thus every pound of extra weight in a "special" I-beam goes into the web. The metal in the flanges of an I-beam is from 2.55 to 2.71 times as efficient in giving flexural strength to the beam as the metal that goes into the web. If, therefore, the web is made thick enough for the work put upon it as well as for the practical requirements of rolling the section, it is economy to put the surplus of metal into the flanges.

How many floors for dwellings, hotels, office buildings or schools require I-beams over 12 ins. deep for the floor beams or joist? Practically none. A floor becomes too expensive for ordinary purposes when over 12-in. beams are needed for the joist; in fact, it is true that 10-in. beams and under are the most economical for that use. With the styles of floor arches most widely used, the maximum spacing is about 5 ft., and on that spacing 10-in. I-beams will carry, over as large a span as current practice demands, the loadings generally adopted for buildings of any of the above-mentioned classes.

On the other hand, the girders which carry these joist are always much deeper than 10 ins., and are usually from 15 to 18 ins., and sometimes 20 or 24 ins. This makes either a floor of uneven thickness or else a very thick one. In the former case it causes architects a great deal of extra trouble to keep these projecting girders over partitions so as not to mar the ceilings of the rooms, and it is one of the principal reasons for using the expensive suspended ceilings. In the other case the accumulated excess in height of some buildings due to extra thickness of floors would sometimes provide an extra story.

That this is a great waste of material, energy and expense no one has ever questioned. Such waste may, however, be avoided by employing special heavy sections of 10-in. or 12-in. I-beams, as designed by the writer. These sections are shown in the accompanying drawing, Fig. 1, which shows their principal dimensions and gives their weight and moment of inertia of section.

The diagram, Fig. 2, has been prepared to show the allowable spans, spacing and loadings of the proposed 12-in. 83.1-lb. beam. (This diagram is similar to a series of diagrams now in course of publication in book form by the Engineering News Publishing Co., covering all of the "standard" and "special" I-beams and channels now rolled by the various mills.) It shows at a glance that for a span of 16 ft. and total load of 200 lbs. per sq. ft. these proposed 12-in. I-beams could be spaced 19 ft. apart, or for a 20-ft. span and 19-ft. spacing the safe load is 130 lbs. per sq. ft.; the weight of metal per square foot of floor area would be 4.37 lbs. in either case. Thus, for a loading of 130 to 140 lbs. per sq. ft., columns could be spaced 19 ft. one way and 20 ft. the other, and yet not require more than 12 ins. depth of floor beams, while if a single "standard" I-beam was used for the girder in this case it would require an 18-in. beam. The former, with the shallow floor, would require 9.37 lbs. per sq. ft., while the latter would require 8.0 lbs. of steel for beams and girders. It will be seen from this comparison, as well as others which can readily be made, that the small excess of steel required for shallow floors is more than compensated for in gain of other building materials and of space. Yours truly, W. F. Scott.

156 Fifth Ave., New York City, July 24, 1902.

(To show the proposed section more clearly in its relation to the sections rolled at present in this country, we have prepared the diagram, Fig.

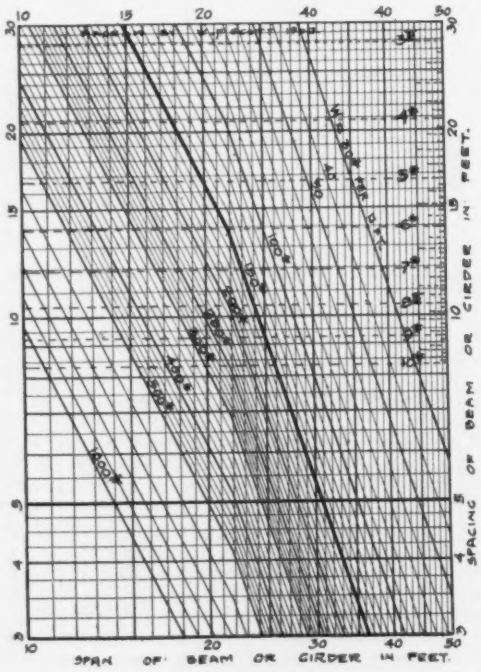

Fig. 2. Diagram of Spans, Spacings and Safe Loads for Proposed Special 12-in. I-Beam.

3. The three outlines show, respectively, the minimum weight standard, the minimum weight special, and the proposed special heavy, 12-in. I-beam; the three cross-sections are superimposed, and one-quarter of the complete diagram is shown.—Ed.)

The Relation of Public Water Supplies to Private Fire Protection, and the Attitude of Insurance Companies Thereto.

Sir: The report of committees of the New England and the American Water-Works Associations on private fire protection, as published in Engineering News of Sept. 18, suggests the question as to what extent a public utility of this character may with reason and fairness be expected to serve a private interest, as commonly viewed. The subject of private fire protection was brought to the attention of the Water-Works Associations largely by reason of issues that have developed through the rapid increase in the number of properties that are being

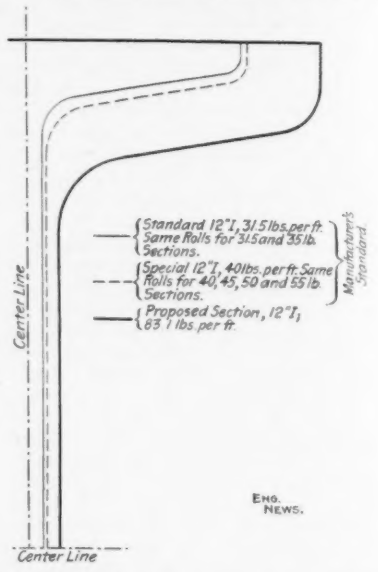
Standard 12"I, 31.5 lbs. per ft. Same Rolls for 31.5 and 35 lb. Sections.
Special 12"I, 40 lbs. per ft. Same Rolls for 40, 45, 50 and 55 lb. Sections.
Manufacturer's Standard.
Proposed Section, 12"I, 83.1 lbs. per ft.
Center Line
Center Line
ENG. NEWS.

Fig. 3. Quarter-Section, Showing Comparison of Carnegie Minimum Weight Standard and Special 12-in. I-Beams, and Proposed Special Heavy 12-in. I-Beam.

equipped with automatic sprinklers. Reference to statistical tables shows that the fire waste in the United States amounts to an enormous sum annually, seldom falling as low as $100,000,000.

Unquestionably the best fire protection is fire prevention, through resourceful and intelligent considerations; but the best scheme for fire extinguishment thus far developed is by the use of automatic sprinklers. Insurance companies are almost compelled, as a measure of self-preservation, to promote the adoption and extension of this method of protection from realization of excessive fire losses, and in their efforts for self-defense they have become large conservators of public safety. Automatic sprinklers are installed under the supervision of insurance companies along lines which have been developed by a scientific study of the subject, which subject in its present development, becomes essentially a scientific and specialized branch of the engineering profession.

The primary function of an automatic sprinkler is the extinguishment of an incipient fire, when a small amount of water is effective with a resultant minimum of loss. Owing to conditions of construction, hazard and occupancy, the limits of its primary functions are exceeded in most cases in varying degrees. It becomes the province of the engineer who is designing such a scheme of fire protection to consider the existing conditions, secure modifications, if possible, of such as are undesirable; design a sprinkler system that shall best meet the requirements of such conditions as must be accepted; and provide water supplies that shall be available at maximum efficiency in all emergencies. Also to provide a system that will operate promptly in a fire emergency without the necessity for manual operation. Whenever the public water service is of such character as to constitute, in the judgment of the engineer, an acceptable source of supply for a sprinkler equipment, he is very glad to avail himself of it; and whether the ownership be municipal or private, operated under a franchise, there would seem to be no good reason why the service required should not be furnished, under suitable and competent controlling conditions.

The question as to what shall constitute suitable controlling conditions is one on which, in some cases, representatives of public water supplies and insurance companies differ widely; and in the experience of the writer, covering a wide territorial range of practice, this difference is usually due to some form of misapprehension or lack of information on the part of the water-works supervisors as to the real value of a properly-designed sprinkler system. The writer would throw around a service of this character from a public source every reasonable safeguard against dishonest practice, or injustice to

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the community, but which should not result in any impairment of its efficiency for the purpose which it is required to serve. The size of such connections, and the arrangement of the same, should be subjects within the discretion of the engineer, who, in the progress of the scientific treatment of automatic sprinkler installation, is now the representative of the insurance companies, and not the water-works. In rare cases only has the writer ever found a superintendent of public water supply who had any scientific knowledge of automatic sprinkler installation, or any adequate conception of sprinkler practice and requirements.

Insurance companies which pay for the installation of sprinkler equipments, and insurance associations which employ competent engineers who have given years to the study of the subject, will not consent to the introduction of obstructive features into a public supply service, without a material modification of some of the beneficiary results of sprinkler installation. The introduction of meters into service connections for fire protection is viewed with disfavor by insurance companies for reasons which from their standpoint are logical and demonstrable, and must result in some measure of prejudice against the property so affected, viewed as a fire risk.

As a consequence of the almost utter lack of knowledge which prevails on the part of water-works representatives with respect to sprinkler installation, the report of the Committee of the American Water-Works Association, on Regulation and Control of Private Services, so far as said services are a factor in sprinkler protection, is apparently based upon an assumption of false premises.

The size of openings for attachments, as per item (6) of that report, is a matter of which few water-works superintendents or engineers have any knowledge whatever regarding adequate requirements; and therefore until they shall have informed themselves respecting the necessities in the case, it is a matter upon which insurance companies cannot accept their decision.

Item (4) of that report, "that the objections of fire insurance companies to the use of meters on private fire-service attachments is not well founded," is apparently based upon a mere assumption of facts and not upon results of tests, nor is it in accord with the principles of automatic fire-protection service. The conflagration hazard of any given congested district is greatly minimized if every building in that district is provided with a properly-designed sprinkler equipment, and the ratio of hazard and danger in a given area is largely a function of the number of sprinkled properties in that area.

This is where the question of private interest affects directly the public safety, and a sprinkled risk, or a number of sprinkled properties become public benefactions; and the argument as to the rights of the client and the obligations of the water company, are by no means all on the side of the water company. It then properly becomes a question, not so much as to what extent a public utility may be expected to serve a private interest, but as to what extent a public utility may reasonably be required to conserve the public welfare.

It is the hope of the writer, who is directly in charge of this feature of fire-protection engineering for the largest underwriting association of stock insurance companies in the United States, covering the largest field of practice, that as the elemental features of sprinkler installation and the value of sprinkler protection becomes better understood and appreciated by those who administer the affairs of public water supplies, they and the insurance companies will unite upon common grounds and with mutual interests, to the end that the best results may be obtained for the greatest number, and the largest value of an established and a carefully handled public service, as is represented by a water-works plant, shall be realized and enjoyed by the community which supports it.

A. W. Hardy,
Chief Inspector, Stock Insurance Companies.
240 La Salle St., Chicago, Sept. 23, 1902.

Notes and Queries.

A contractor writes us that he has heard of a dump car for construction work which has a body set low on the trucks so that it runs steadily on rough track. When the car reached the point where it is desired to dump, the brakes are set or the car is chocked and the horse or other motive power is detached from the draw bar and attached to a second draw bar connected to mechanism that elevates the car body as traction is applied. In this way the body is raised by power high enough to be dumped, and it is then lowered back to its first position. The advantages of a car of this sort are obvious and our correspondent desires to learn the name and address of its manufacturers.

THE ONTARIO ROUTE FOR A BARGE CANAL VS. THE SENECA-ONEIDA-MOHAWK ROUTE.

By T. W. Symons,* Major, Corps of Engineers, U. S. A.

After very careful investigation and consideration, the friends and advocates of an enlarged Erie Canal, having all available facts before them, have decided that the route to be adopted for the proposed barge canal shall be through the interior of the State by way of the Seneca and Oneida rivers, Oneida Lake and the Mohawk River, and not by the Lake Ontario route, and in a published statement gives reasons therefor. In Engineering News of Sept. 11, this selection was questioned, and an attempt was made to refute the statements and arguments used. I therefore beg the privilege of presenting again in a somewhat different form the reasons for selecting the interior route, and answering some of the published arguments and statements against it.

In the first place, it may be stated that prior to the construction of the Erie Canal, the Ontario route was for a hundred years and more the main traveled highway between the East and West. Its good and bad qualities, and all the points in its favor and against it were well known to our forefathers, when they decided against it, and in favor of a canal in almost entirely an artificial cut through the interior of the State. So the question is not a new one, being older than the Erie Canal itself. As our forefathers wisely decided against the Ontario route, so to-day I believe the advocates of canal enlargement have wisely decided against it.

I believe, too, that it can be stated with perfect confidence that the choice of routes receives practically the unanimous approval of every friend of the canals who is familiar with lake and canal navigation, and who is unhampered in his judgment. The advocates of the Ontario route are those who are unfamiliar with these questions, who have some local axes to grind, or those who, like the Engineering News, are avowedly opposed to the radical improvement of the canal on any route.

It is, of course, very alluring to think that by adopting the Ontario route $20,000,000 can be saved over adopting the interior route, and there must be strong reasons to justify its being turned down in favor of the more expensive route.

The principal objections to the Ontario route are the following:

(1) Boats, whether made of wood or of steel, must necessarily be made much heavier and stronger if they are to traverse the wide waters of Lake Ontario, than if they are to be confined like the ordinary canal boats of to-day to the narrow interior waterways. Of course, there probably would be boats built capable of going into the Great Lakes, but the vast majority of the business on the canal would certainly be done by canal boats built as cheaply and as light as practicable and suited to the narrow protected waterways. For the purpose of strengthening the argument that all canal boats would be practically alike and capable of navigating the lakes, the allusion by the Engineering News to the successful operation of fleets of steel canal boats running to Cleveland was unfortunate, as these boats have been found to be unsuccessful, and have been taken off the route, sold and taken out of the country. The perils and detentions due to navigating Lake Erie with them was undoubtedly the principal element to which their lack of success was due. The manager of the line felt this keenly, and once in conversation with the writer told him that he was seriously contemplating the construction of a huge steamer like a floating dry dock into which the loaded canal boats could be floated, the steamer then pumped out and the passage made between Cleveland and Buffalo, where the boats would be removed and then proceed about their business on suitable waters. It is my understanding that plans for such a vessel were prepared, but it was never built. The whole incident of these steel Cleveland canal boats illustrates very forcibly the practical difficulties of navigating the waters of the lakes and the canal by the same boats.

There is nothing truer than that the highest economy demands that business should be done on the ocean, lakes, rivers and canals in vessels suited to the different types of waters.

Now the practical objection to the heavier vessel for ordinary canal work is that every ton extra put into the construction of the boat means a ton less in freight-carrying capacity, as the size of the locks limits the size of the boat to a definite figure. A canal boat of the size proposed suited to lake navigation will exceed one suited for the canal alone, by about 100 tons, and hence every trip the lake boat is handicapped by its inability to carry within 100 tons as much as the canal boat proper. With a fleet of four boats this would mean 400 tons each way.

The Ontario canal route would therefore have at least 10% less carrying capacity in the vessels adapted to its use, than would the interior route.

(2) As the boats suited for the lake route would be much heavier, so they would be much more expensive, involving a heavier outlay and interest charges. The dictum of the Engineering News that the days of wooden canal boats are over cannot be accepted. I have every reason to believe that if the barge canal were built, many wooden canal boats suitable to navigate it would be built. But whether wood or steel be used, the cost of boats of either material suitable to navigate the lake would be much greater than the cost of boats of the same material suitable to navigate the interior canal only. This increase is fairly and reasonably estimated at 50%.

(3) The cost of insurance on vessels and cargoes using the lake route would be very much greater than on those using the interior route. The dangers of the lake route to a string of towed motorless barges along a lee shore are very well known to lake marine insurance men, and these dangers would, according to them, cause the insurance rates to be at least double the rates for the inland route. This is a very serious and important item. As it is the insurance rates on the lower St. Lawrence that militate so much against this route, so it would be the insurance rates that would militate against the Lake Ontario canal route.

(4) It does not do to belittle the dangers and delays to fleets of canal boats attempting to navigate Lake Ontario, especially in the spring and fall, when the need of the canal for the transportation of the products of the West is at its highest. During a part of September and most of October and November the prevalence of storms would render the navigation of Lake Ontario by fleets of canal boats exceedingly hazardous, and indeed almost impracticable.

After personally navigating this lake for four years and having charge of its harbors and lighthouses and studying its characteristics, I do not hesitate to express the opinion that the delays due to bad weather on this lake route will far more than offset the slower time that boats would make through the interior canal, and especially so at the busy time of the year. This latter would, moreover, have the element of certainty and ability to run on schedule time which would be lacking in the lake route.

(5) The great argument for a barge canal is not confined to its benefit to through business by any means. Far-sighted and broad-minded canal advocates see in the barge canal greater benefit to the State by building up manufactories and industries of many and varied kinds all through the State along its route than would come from the through business. A barge canal would give to every point along its course nearly all the advantages of a seaport and a lake port, and the development of local commerce and manufactures along its route would, it is believed, be enormous, and this in turn would very greatly benefit the farmers of the State, giving to them local markets for their produce.

The Lake Ontario route would be vastly inferior in respect to local State benefits to the proposed inland route.

(6) It hardly does, in the study of the great transportation problems confronting us, to ignore the efforts of Canada to attract commerce. The Welland and St. Lawrence canals are an accomplished fact, and Canada is now building a great breakwater and elevators at Port Colborne, and is building others at Montreal and Quebec, and she has entered into contract with a powerful American organization to deliver through her doors a large amount of commerce during the next ten years, and ships to do the business are now being built. Moreover, she is straining every nerve to reduce the difficulties of navigating the lower St. Lawrence and rob it of its terrors, by building numerous lighthouses and fog signal stations. What the end will be no one can tell. It at least

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is hardly proper to cast aside with a sneer the strenuous efforts of such a splendid country as Canada.

It is an unquestionable fact that the barge canal by way of Lake Ontario might play into the hands of Canada, while by its interior route it could not. If New York should expend the money required for the canal she should have the accruing advantages, and not expend it in such a way as might largely rob here of her commence.

(7) There would be little difference in the cost of maintenance of the canal by either route, for it must be remembered that by the interior route proposed, at least two-thirds of the way from Albany to Buffalo will be in natural water courses, on which the cost of maintenance would be very small. The extra cost of maintaining the inland route in some respects will be made up by the extra cost of the lake route in other respects, particularly in operating the additional locks required, for there will be about 270 ft. more of lockage by the lake than by the inland route, and by the cost of maintaining harbors and mooring stations.

The article in the News concludes by saying: "The proposed 1,000-ton barge canal is a huge experiment. If it is to have a trial, let it be a fair one." It is hard to see how any business venture could be less of an experiment than this canal would be, but assuming that it is an experiment, I echo the sentiment that it should be a fair one. And to be a fair experiment I venture to suggest that the route by which it is built should be selected by friends who have given the subject careful and long-continued study, and desire its success, and not by its enemies, who predict and expect its failure. Personally, I am ready to concede now that a barge canal built by the Ontario route would be a failure, for it is so handicapped by natural conditions that it could never reduce the cost of transportation sufficiently to enable it to compete with the existing antiquated Erie Canal.

RESULTS OBTAINED IN EQUALIZING THE TEMPERATURE OF HOT BLAST.*

By Lawrence F. Gjers and Joseph H. Harrison,† M. Inst. C. E.

The authors read before this Institute in May, 1900, a short paper describing an apparatus for converting hot blast of that irregular temperature which is unavoidable when using regenerative stoves, into hot blast of regular temperature, for use in blast furnaces, with a view to

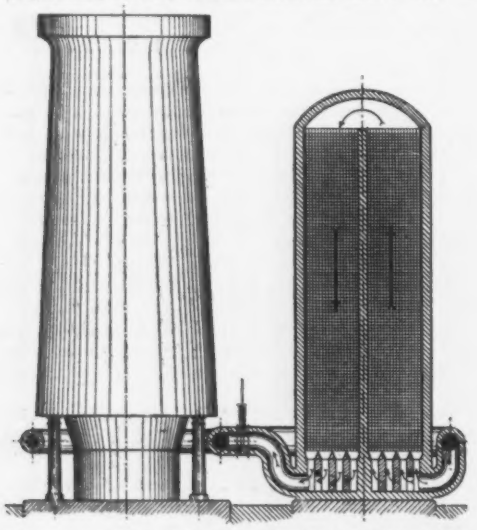

Fig. 1. Section of Equalizer for Hot Blast Supply to Blast Furnace.

obtaining greater regularity in furnace working, and in quality of iron produced.

At that time there was not an equalizer at work, but one was being erected at the Normanby Iron Works, Middlesbrough, in connection with a new furnace. This was put to work on May 6, 1901, and has worked continuously from that date, without having once been stopped, and without having cost a penny in either repairs or attention of any kind.

*A paper read at the Duesseldorf Meeting of the Iron and Steel Institute.

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The equalizer is shown in section in Fig. 1, and is much the same shape as a Cowper stove, 20 ft. diameter by 55 ft. high, built of steel plates, and lined with firebrick. A central division wall from the bottom to near the dome, divides it into two similar sections, which are filled with firebrick chequer work.

The hot blast of irregular temperature as it leaves the stoves is made to enter at the bottom of one of these sections. It passes up through the chequer work of that section and down through that of the other section, and is passed out at the bottom at a perfectly uniform temperature. It is then carried to the furnace by suitable connections.

The excessive heat of the blast given by a stove which has just been put on blast after heating up, when it enters

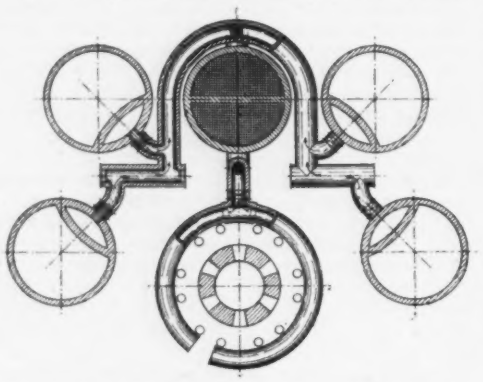


Fig. 2. General Plan of Equalizer Connected to Blast Furnace Having Four Stoves.

the equalizer, comes at once in contact with the chequer work of the inlet section, which has been partially cooled down by the reduced temperature of the blast given by the stove which has just gone off to be heated up. The hot blast parts with some of its heat to the chequer work, the temperature of which is thereby raised.

As the run of this stove proceeds, its heat is lowered, and the temperature of the blast it gives gradually falls below the temperature of the chequer work of the equalizer, and the chequer work then returns to the blast the excess of heat which it took up in the early part of that stove's run. There is thus an exchange of heat continually going on between the chequer work and the hot blast in either one direction or the other, with the result that the temperature of the blast issuing from the equalizer remains constant, at practically the mean of the varying temperature of the blast given by the stoves when going on and going off blast.

The furnace at the Normanby Iron Works is provided with three Ford & Moncur stoves, the hot blast from which is collected into a common main 24 ins. internal diameter, passing behind the furnace and round to the back of the equalizer, being connected directly to it near the bottom.

After passing up one section and down the other, the blast leaves the equalizer by a 24-in. connection, which, turning upward, has two branches leading off to the horseshoe main round the furnace. In building this equalizer an air space of 2 ins. was left between the shell and the firebrick lining, but it was found in working that about 50° F. was lost from the blast by radiation and conduction. To prevent this loss the whole of the outside of the shell was covered 2 ins. thick with a composition consisting chiefly of slag wool, with the result that the loss now is below 25° F. In future equalizers it is proposed to pack 2 or 3 ins. of slag wool between the shell and the firebrick lining.

The equalizer is perfectly automatic, and requires no attention of any kind whatever; and there is no reason to expect that any more repairs will be required to it than to any ordinary hot-blast main.

On comparing this system with that of leveling or reducing the hot-blast temperature to the minimum temperature given off by the stoves, by the admission of cold blast, for the purpose of regularity, so largely adopted in America, and to a less extent in this country, it will be seen how very much easier the one is to work than the other. In one case the stoveman has to be continually shutting off a little cold blast every few minutes during the run of a stove, and when that stove goes off and another on, he has to open out the cold-blast valve again until he finds by his pyrometer he has got the temperature he is ordered to keep, and then he begins to go through the same gradual shutting off of the cold blast as before, and so on night and day.

In this way a fairly regular blast temperature may be maintained, but it is at the minimum temperature at which the stoves go off blast, and is only possible by the continuous and careful attention of the stoveman.

In the other case a more perfect regularity of blast temperature is maintained without the least attention from the stoveman, and practically at a mean between that at which the stoves go on and go off blast.

It may be argued that in the former case there is always available a higher heat of blast should the furnace require it for a short time. The same is true working with the equalizer, for by providing a bye-pass from the hot-blast main (before it reaches the equalizer to the horseshoe main the blast from a freshly heated stove can be made to pass direct to the furnace without going through the equalizer. Or, if the reducing valve above referred to is preferred, a cold-blast connection can be made to the hot-blast outlet from the equalizer and the temperature of the blast lowered to any extent desired. The cold-blast valve, once set to give the proper temperature, would require no further attention, unless higher temperature was required, when it could be partly or wholly closed. At the same time it does not seem advisable, for the sake of getting a higher temperature now and then, to work the furnace regularly on a reduced temperature of blast.

Figs. 1 and 2 show in elevation and plan one arrangement of an equalizer working in conjunction with four stoves and a furnace, but each equalizer will have to be arranged to suit local circumstances.

AN ELECTRIC TRACTION SYSTEM EMPLOYING SINGLE-PHASE ALTERNATING CURRENT.

In our issue of Sept. 11 we noted briefly that an interurban electric railway was to be constructed in the near future between the cities of Baltimore, Washington and Annapolis, Md., which was to operate on a radically new system of electric traction. Alternating current, single-phase, was to be distributed at high voltage from a central power station, and transformed to a pressure of something like 1,000 volts by static transformers placed along the line, feeding the trolley wire; this 1,000-volt single-phase current was to be utilized directly in the motors of the car.

A practicable system of this type has for years been dreamed of and sought for by electrical engineers. The point of difficulty was the motor. All the other elements of the necessary electrical equipment have long been commercial articles, but none of the existing alternating-current motors possessed the qualities that were required for traction work. The one whose characteristics came nearest to meeting the conditions, the polyphase induction motor, was still far from satisfactory, and the best that could be said for it was that engineers hoped it might yet be developed into a suitable machine. Moreover, the use of this motor meant a number of supply conductors, such as three trolley wires, or two wires with a rail return; this was recognized to be a complication that argued seriously against the system. In spite of these facts, European engineers have of late years held such strong belief in this system that they actually applied it on a number of railway lines; as will be remembered, the elaborate and expensive high-speed experiments on the Berlin-Zossen line in Germany were also made exclusively with a polyphase induction motor system.

Meanwhile the direct-current traction system has been greatly developed, especially in America, so that it has become quite thoroughly standardized. Series motors on the car, a line-pressure of 500 to 600 volts, and for long lines polyphase alternating-current distribution with conversion in rotary converter substations, are the principal features of a system of excellent efficiency and reliability. Any alternating-current system to be generally preferable would have to equal or exceed the advantages of direct-current traction, with no greater disadvantages. If it could meet these conditions, it would further have to be economical to install, having only the small margin of advantage over the direct-current system which lies in saving the rotary converter substations required in the latter.

Yet there has been a strong and growing conviction among electrical engineers, especially in America, that in order to make an assured future for electric traction on main-line railways it was necessary that a successful system of alternating-current working be developed, and it has seemed equally necessary that such a system be single-phase. The problem of developing such a system was thus rendered attractive not only by its many difficulties, but also and in a much greater degree by its importance and by the great rewards it seemed to offer to success.

The interest involved in the new system to be applied to the Washington, Baltimore & Annapo-

lis Ry. will be readily understood from the preceding. Hitherto no information as to the nature of the essential details of the system has been available; but at the meeting of the American Institute of Electrical Engineers, held on Sept. 26, a paper was read by Mr. B. G. Lamme, which made public the first details as to the new system. Mr. Lamme has been in direct charge of working out the system for the Westinghouse Electric & Mfg. Co., and the information thus had the added interest of being at first hand. The paper was read at the society's first meeting of the season, before a crowded house, assembled largely on direct account of the paper. A large number of engineers prominent in electrical progress listened to the paper, and afterward spoke in discussion.

In the following we present an abstract of Mr. Lamme's paper, and of the succeeding discussion. Besides the matter which we reproduce, an analysis of the defects of direct-current traction was embodied in the paper. This portion, being only of secondary interest, we have omitted, and we reprint the portion referring directly to the apparatus in course of construction for the railway line already mentioned. While the paper describes this in sufficient detail to make clear the distinctive features of the new system, the electrical details of the central matter, the motors, are not described, and on being questioned about these in discussion, Mr. Lamme stated that further data could not be given at present. This considerably reduced the value of the discussion, which was necessarily quite general. Nevertheless, the technical details being taken for granted, the paper is a full description of the new system, especially so because results of actual tests on the motors are shown in curves accompanying the paper and here reproduced:

THE WASHINGTON, BALTIMORE & ANNAPOLIS SINGLE-PHASE RAILWAY.

The problem (of single-phase alternating-current railway working—Ed.) resolves itself into the construction of a single-phase motor having the characteristics of the direct-current series motor.

There are several types of single-phase alternating-current motors which have the series characteristics. One type is similar in general construction to a direct-current motor, but with its magnetic circuit laminated throughout, and with such proportions that it can successfully commutate alternating current. Such a motor is a plain series motor, and can be operated on either alternating or direct current and will have the same torque characteristics in either case. Another type of motors is similar in general construction to the above, but the circuits are arranged in a different manner. The field is connected directly across the supply circuit, with proper control appliances in series with it. The armature is short-circuited on itself across the brushes, and the brushes are set at an angle of approximately 45° from the ordinary neutral point. The first of these two types of motors is the one best adapted for operation in large units.

This is the type of motor which is to be used on the Washington, Baltimore & Annapolis Ry. Several motors have been built and tested with very satisfactory results, both on the testing stand and under a car. The results were so favorable that the system was proposed to the Cleveland Engineering Co., representing the Washington, Baltimore & Annapolis Ry., and after investigation by their engineers, it was adopted. A description of the apparatus to be used on this road will illustrate the system to good advantage.

Single-phase alternating current will be supplied to the car at a frequency of 16⅔ cycles per second, or 2,000 alternations per minute. The current from the overhead trolley wire is normally fed in by one trolley at approximately 1,000 volts. Within the limits of the District of Columbia two trolleys are employed, by Act of Congress the use of rails as conductors is prohibited in this district, presumably on account of electrolysis. In this case the trouble, of course, will not exist (since alternating current is used), but the contracting company has been unable to obtain permission for the grounded circuit.

The alternating current to the car is carried through a main switch or circuit breaker on the car, to an auto-transformer connected between the trolley and the return circuit. At approximately 300 volts from the ground terminal, a lead is brought out from the auto-transformer and passes through a regulator to one terminal of the motors. For starting and controlling the speed, an induction regulator is used with its secondary winding in series with the motors. This secondary circuit of the regulator can be made either to add to, or subtract from the transformer voltage, thus raising or lowering the voltage supplied to the motors. The regulator therefore does double duty. The controller for direct-current motors merely lowers the voltage supplied to the motors but cannot raise it, but an alternating-current regulator can be connected for an intermediate voltage, and can either raise or lower the motor voltage. In this way the regulator can be made relatively small, as it handles only the variable element of the voltage and the maximum voltage in the secondary winding is but half of the total variation required.

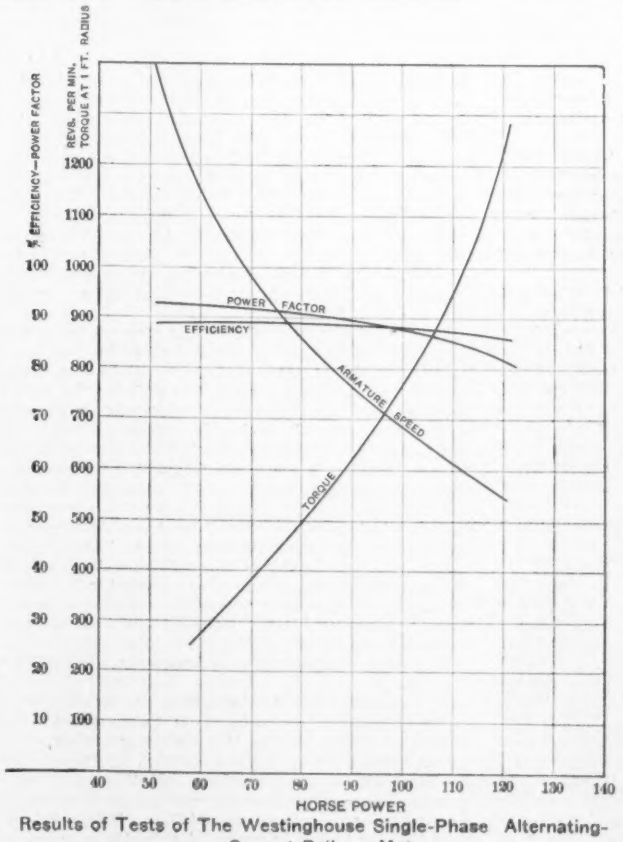
In the equipments in question, the range of voltage at the motor is to be varied from approximately 200 volts up to 400 volts or slightly higher. The transformer on the car will supply 315 volts, and the secondary circuit of the regulator will be wound to generate slightly more than 100 volts when turned to the position of its maximum voltage. This voltage of the regulator is about one-fourth of that of the motors at full voltage. The regulator can consequently be made relatively small, in comparison with the motor capacity of the equipment. It has been found unnecessary to use much lower than 200 volts in this installation, as this allows a comparatively low running-speed, and approximately 200 volts will be necessary to start with the required torque. The greater part of this voltage is necessary to overcome the e. m. f. of self-induction in the motor windings, which is dependent upon the current through the motor and is independent of the speed of the armature.

There will be four motors of 100 HP. on each car. The full rated voltage of each motor is approximately 220 volts. The motors are arranged in two pairs, each consisting of two armatures in series, and two fields in series, and the two pairs are connected in parallel. The motors are connected permanently in this manner. Since voltage control is used, there is no necessity for series parallel operation, as with direct-current motors. To ensure equal voltage to the armatures in series, a balancing or equalizing action is obtained by the use of a small auto-transformer connected permanently across the two armatures in series with its middle point connected between them. The fields are arranged in two pairs, with two fields in series and two pairs in multiple. This parallels the fields independently of the armatures, which was formerly the practice with direct-current motors. It was a defective arrangement with such motors, as equal currents in the field did not ensure equal field strengths in the motors, and the armatures connected in parallel would therefore be operating in fields of unequal strength, with unequal armature currents as a direct result. With alternating currents in the fields, the case is different. The voltage across the fields is dependent upon the field strengths, and the current supplied to the fields naturally divides itself for equal magnetic strengths. The chief advantage in paralleling the fields and armatures independently is, that one reversing switch may serve for the four motors and one balancing transformer may be used across the two pairs of armatures. The ordinary direct-current arrangement of armatures in series with their own fields can be used, with a greater number of switches and connections.

The induction regulator or controller, resembles an induction motor in general appearance and construction. The primary winding is placing on the rotor, and the secondary or low-voltage winding on the stator. The rotor also has a second winding which is permanently short-circuited on itself. This function of this short-circuited winding is to neutralize the self-induction of the secondary winding as it passes from the magnetic influence of the primary. The regulator is wound for two poles, and therefore is operated through 180° for producing the full range of variation of voltage for the motors. One end of the primary winding of the regulator is connected to the trolley, and the other to a point between the regulator and the motors. It thus receives a variable voltage as the controller is rotated. There are several advantages in this arrangement of the primary in this particular case. First, the regulator is worked at a higher induction at start, and at lower induction when running, the running position being used in these equipments for much longer periods than required for starting. Second, when the motors are operating at full voltage the current in the primary of the regulator passes through the motors but not through the auto-transformer or the secondary of the regulator. This allows considerable reduction in the size of auto-transformer and regulator.

The motors on the car are all of the straight series type. The armature and fields being connected in series, the entire current of the field passes through the armature as in ordinary series direct-current motors. The motor has eight poles, and the speed is approximately 700 r. p. m. at 220 volts. The general construction is similar to that of a direct-current motor, but the field core is laminated throughout, this being necessary on account of the alternating magnetic field. There are eight field-coils wound with copper strap, and all connected permanently in parallel. The parallel arrangement of field-coils assists in the equalizing of the field strength in the different poles, due to the balancing action of alternating circuits in parallel. This arrangement is not really necessary, but it possesses some advantages and therefore has been used. With equal magnetic strength in the poles, the magnetic pull is equalized even with the armature out of center. The armature is similar in general construction to that of a direct-current motor.

The fundamental difficulty in the operation of a commutator type of motor, on single phase alternating current lies in the sparking at the brushes. The working current passing through the motor should be practically no more difficult to commutate than an equal direct current, and it is not this current which gives trouble. The real source of trouble is found in a local or secondary current set up in any coil, the two ends of which are momentarily short-circuited by a brush. This coil encloses the alternating magnetic field, and thus becomes a secondary circuit of which the field-coil forms the primary. In the motors of the Washington, Baltimore & Annapolis Ry., this commutation difficulty has been overcome by so constructing the motor that the secondary or short-circuit current in the armature coil is small, and the commutating conditions so nearly perfect that the combined working and secondary currents can be commutated without sparking. This condition being obtained, the motor operates like a direct-current machine and will give no more trouble at the commutator than ordinary direct-current railway motors. Experience covering a considerable period in the operation of motors of 100-HP. capacity indicates that no trouble need be feared at the commutator.



Results of Tests of The Westinghouse Single-Phase Alternating-Current Railway Motor.

An extended series of tests were made with these motors at the Westinghouse shops at East Pittsburg, both in the testing room and under a car. The accompanying figure shows curves of the speed, torque, efficiency and power factor plotted from data from brake tests. It will be seen from these that the efficiency is good, being very nearly equal to that of high-class direct-current motors. The power factor, as shown in these curves, is highest at light loads and decreases with the load. This is due to the fact that the power developed increases approximately in proportion to the circuit, while the wattless component of the input increases practically as the square of the current. The curve indicates that the average power factor will be very good. The calculations for the Washington, Baltimore & Annapolis Ry. show that the average power factor of the motors will be approximately 86%.

The average efficiency of these equipments will be much higher during starting and accelerating than that of corresponding direct-current equipments, as rheostatic losses are avoided. When running at normal full speed, however, the efficiency will be slightly less than with direct current. This is due to the fact that the motor efficiency is slightly lower than in the case of direct current, and in addition there are small losses in the

transformer and the regulator. The alternating-current equipments are somewhat heavier than the direct current, thus requiring some extra power, both in accelerating and at full speed. Therefore, for infrequent stops the direct-current car equipment is more efficient than alternating current, but for frequent stops the latter shows the better efficiency. Tests on the East Pittsburg track verified this conclusion. But the better efficiency of the direct-current equipment with infrequent stops is offset with the alternating current by decreased losses in the trolley wire, by reason of the higher voltage used and the elimination of the rotary converter losses. The resultant efficiency for the system will therefore be equal to or better than that of the direct-current system. In the Washington, Baltimore & Annapolis Ry. contract the guarantee given by the Westinghouse Electric & Mfg. Co. states that the efficiency of the system shall be equal to that of the direct-current system with rotary converter substations.

There is one loss in the alternating-current system which is relatively much higher than in the direct-current. This is the loss in the rail return. Tests have shown that at 2,000 alternations this is three to four times as great as with an equal direct current. This would be a serious matter in cases where the direct-current rail loss is high. But the higher trolley voltage reduces the current so much that the alternating-current rail loss is practically the same as with direct current at usual voltages. In many city railways the direct-current rail loss is made very low, not to lessen waste of power, but in order to reduce electrolysis. In such cases the alternating-current rail loss could be higher than direct current, thus decreasing the cost of return conductors. More numerous transformer substations, with copper feeders connected to the rails at short intervals will enable the rail loss to be reduced to any extent desired.

As a frequency of 2,000 alternations per minute is used, the lighting of the cars and the substations was at first considered to be a serious difficulty, due to the very disagreeable winking of ordinary incandescent lamps at this frequency. Two methods of overcoming the winking were tried, both of which were successful. One method was by the use of split phase. A two-phase induction motor was run on a single-phase 2,000-alternating circuit, and current was taken from the unconnected primary circuit of the motor. This current was, of course, at approximately 90° from the current of the supply circuit. A two-phase circuit was thus obtained on the car. Currents from the two phases were put through ordinary incandescent lamps, placed close together. The resulting illumination a few feet distant from the lamps showed about the same winking as is noticed with 3,000 alternations. With two filaments in one lamp the winking disappears entirely. A three-phase arrangement would work in the same way. A much simpler method was tried which worked equally well. This consisted in the use of very low-voltage lamps. Low voltage at the lamp terminals allows the use of a thick filament with considerable heat inertia. Tests were made on lamps of this type at a frequency of 2,000 alternations, and the light appeared to be as steady as that from the ordinary high-frequency incandescent lamp. The low voltage is not objectionable in this case, as a number of lamps can be run in series, as in ordinary street railway practice, and any voltage desired can readily be obtained as alternating current is used on the car.

There will be an air compressor, driven by a series alternating-current motor, on each car, for supplying air to the brakes and for operating the driving mechanism of the controller. The details of this mechanism are not near enough to completion to permit a description of it. The method used will be one which readily allows operation on the multiple-unit system.

The generating station contains some interesting electrical features, but there is no great departure from usual alternating-current practice. There will be three 1,500-KW. single-phase alternators. These are 24-pole machines operating at 83 r. p. m. and wound for 15,000 volts at the terminals. They are of the rotating field type, with laminated magnetic circuits and field-coils of strap on edge. The field-coils are held on the pole-tips by copper supports, which serve also as dampers to assist in the parallel running. The armatures are of the usual slotted type. The armature coils are placed in partially closed slots. There are four coils per pole. The proportions of these machines are such that good inherent regulation is obtained without saturation of the magnetic circuit. The rise in potential with non-inductive load thrown off will be approximately 4%. An alternative estimate was furnished for the generators proposing 20,000 volts instead of 15,000. The simplicity of the type of winding used, and the low frequency, are both favorable for the use of very high voltage on the generator. As 15,000 volts was considered amply high for the service, the engineers for the railway considered it unadvisable to adopt a higher voltage.

There are to be two exciters, each of 100-KW. capacity at 250 r. p. m. The exciters are wound for 125 volts normal. The armature of each exciter has, in addition to the commutator, two collector rings, so that single-phase alternating current can be delivered. It is the intention to use the exciters as alternators for supplying current to the system for lighting when the large generators are shut down at night.

The main station switchboard comprises three generator panels, one load panel, and three feeder panels. High-tension oil-break switches are to be provided, operated by means of controlling apparatus on the panels. The switches, bus-bars and all high-tension apparatus will be in brick compartments separate from the board. In each generator circuit there are two non-automatic oil-break switches in series; and on each feeder circuit there are two over-load time-limit oil-break switches in series. The two oil-break switches in series on the same circuit can be closed separately and then opened to test the switches without closing the circuit. With the switches in the closed position they are both operated at the same time by the controlling apparatus, to ensure opening of the circuit, and to put less strain on the switches, although either one is capable of opening the load.

There will be nine transformer substations distributed along the railway line. Each station will contain two 250-KW. oil-cooled lowering transformers, supplying approximately 1,000 volts to the trolley system. Two transformers are used in each station so that in case of accident to one transformer the station will not be entirely crippled.

It is the intention of the railway company to operate a direct-current road already equipped with the direct-current system. The present direct-current car equipments are to be retained, but the current will be supplied from a rotary-converter substation fed from the main system of the Washington, Baltimore & Annapolis Ry. As this system is single phase, it is necessary that single-phase rotaries be used in the substations. There are to be two 200-KW. 550-volt rotary converters. These are 4-pole, 500 r. p. m. machines. The general construction of these machines is very similar to that of the Westinghouse polyphase rotary converters. The armature resembles that of a polyphase rotary except in the number of collector rings, and in certain details of the proportions made necessary by reason of the use of single phase. The commutating proportions are so good that any reactions due to the use of single phase will result in no injurious effect. The field construction is similar to that of a polyphase rotary. The laminated field-poles are provided with dampers of the "grid" or "cage" type, a form used at present in the Westinghouse polyphase rotary converters. These dampers serve to prevent hunting, as in the polyphase machines, and also to damp out pulsations due to single-phase currents in the armature. The dampers act to a certain extent like a second phase. Each rotary converter is started and brought to synchronous speed by a small series alternating-current motor on the end of the shaft. The voltage at the motor terminals can be adjusted either by loops from the lowering transformer or by resistance in series with the motor, so that true synchronous speed can be given to the rotary converter, before throwing it on the alternating-current line.

From the preceding description of this system and the apparatus used on it, some conclusions may be drawn as to the various fields where it can be applied to advantage. It is evident that a good field for it will be on interurban long-distance lines such as the Washington, Baltimore & Annapolis Ry. On such railways, high trolley voltage and the absence of converter substations are very important factors. For heavy railroading also, this system possesses many ideal features. It allows efficient operation of large equipments at practically any speed and any torque, and also avoids the controller troubles which are ever present with large direct-current equipments. It also permits the use of high trolley voltage, thus reducing the current to be collected. In this class of service the advantages of this alternating-current system are so great that it is possible that heavy railroading will prove to be the special field for it.

For general city work, this system may not find a field for some time to come, as the limitations in the present system are not so great that there will be any urgent necessity for making a change. It is probable that at first this system will be applied to new railways, or in changing over steam roads rather than in replacing existing city equipments. One difficulty with which the new system will have to contend, is due to the fact that the alternating-current equipments cannot conveniently operate on existing city lines, as is the present practice where interurban lines run into the cities. It will be preferable for the alternating-current system to have its own lines throughout, unless very considerable complication is permitted. When the alternating-current system applied to interurban and steam railways finally becomes of predominant importance, it is probable that the existing direct-current railways will gradually be changed to alternating current as a matter of convenience in tying the various lines together.

As was stated above, alternating-current equipments cannot conveniently be operated on direct-current lines. It does not follow, however, that the motor will not operate on direct current. On the contrary, the motor is a first-class direct-current machine, and if supplied with suitable control apparatus and proper voltage it will operate very well on the direct-current lines. This would require that the motors be connected normally in series, as the voltage per motor is low. A complete set of direct-current control apparatus would be needed when the equipment is to be run on direct current, and considerable switching apparatus would be necessary for disconnecting all the alternating-current control system and connecting in the direct current. The complication of such a system may be sufficient to prevent its use, at least for some time to come.

In some cities, very strict laws are in force with regard to the voltage variations in various parts of the track system. The permissible variations are so small in some cases that an enormous amount of copper is used for return conductors; and in some cases special boosters are used in the return circuits to avoid large differences of potential between the various parts of the track system. The object in limiting the conditions in this manner is to avoid troubles from electrolysis. The alternating-current system will, of course, remedy this.

For city work, it is probable that voltages of 500 or 600 would be employed instead of 1,000 or higher. The transformers and controllers can be designed to be readily changed from full to half voltage, so that low voltage can be used on one part of the line and high voltage on another. As the car equipments of such railways are usually of small capacity, it is probable that speed control will be obtained by means of a transformer with a large number of leads carried out to a control drum, rather than by means of the induction regulator, as the latter device is much more expensive in small units. This is chiefly a question of cost, and if the advantages of the induction regulator are found to overweigh the objection of high first cost, then it will be used even on small equipments.

In the Washington, Baltimore & Annapolis Ry. the generators are wound for single phase. In the case of large power stations with many feeders, the generators may be wound for three phase, with single-phase circuits carried out to the transformer substation; or three-phase transmission may be used, with the transformers connected in such a manner as will give a fairly well-balanced three-phase load.

There are many arrangements and combinations of apparatus made possible by the use of alternating current in the car equipments, which have not been mentioned, as it is impracticable to give a full description of all that can be done. But enough has been presented to outline the apparatus and to indicate the possibilities of this new system which is soon to see the test of commercial service.

DISCUSSION.—The chairman requested Mr. C. P. Steinmetz to open the discussion. Mr. Steinmetz expressed his pleasure at seeing from the paper that the problem of alternating-current traction had been attacked by American engineers in what he considered the right way—on the basis of single-phase motors. There is at present much enthusiasm in European engineering circles over polyphase traction, using induction motors, but very little of this has affected American engineers. That same ground had all been gone over years ago in this country, as early as '94, and since then, as renewed stimulus came from Europe, it has been covered again and again, with always the same conclusion: rejection of the system.

Mr. Steinmetz recalled that he had experimented with the type of motor employed by Mr. Lamme, as much as ten years ago, with Mr. Eickemeyer. They had tried many modifications, but could never get rid of the vicious commutating spark. But they had worked with considerably higher frequencies and lower speeds than Mr. Lamme, which to some extent accounted for their poorer results in this respect as well as their lower power factor. The speaker was sorry to see that the type of motor which he had most faith in was only incidentally mentioned in the paper—the Thomson repulsion motor. If the induction motor be considered analogous to the direct-current shunt motor, then in like manner we would derive from the direct-current series motor the alternating-current repulsion motor. The speaker still held the belief that this type would yet be developed to a point where it would prove the true solution of the problem of the alternating-current railway motor.

Mr. R. D. Mershon was glad to see a successful motor developed for alternating-current work, as in the paper. Notwithstanding the results shown, however, and while recognizing the insufficiency of the present induction motor, he still had not lost faith in the induction motor. A type would yet be developed, he felt, that would operate at fair and uniform efficiency and without the faults of the present type. He asked details of Mr. Lamme as to the methods used to avoid sparking in his motor, the relation between the number of poles and the power factor, etc.

Mr. B. J. Arnold expressed pleasure at seeing one of the large manufacturing concerns take up the alternating-current motor, where in the past they were hostile to it. He would sum up the paper by saying that a single-phase series motor had been developed that will not spark at the commutator. If this same good result is uniformly obtained on a commercial scale, then the author will deserve even greater commendation. As to his own single-phase traction system, he stated that in a few months he would present to the society a full description, with drawings and photographs, of the 60-mile line which he

has equipped and which is about ready to begin operation. He reminded the society, however, that contrary to a statement in the paper the Washington, Baltimore & Annapolis Ry. would not be the first single-phase railway in this country, but that this distinction belonged to his own line.

Mr. C. O. Mailloux made some remarks to the effect that he had always favored the direct-current traction system, and that he could not yet change that conservative view. On the contrary, he believed that the direct-current system might yet be developed to a point where it would be rid of its present faults and suited for a larger field of use.

Mr. H. A. Wagner stated that he had seen experiments made with the single-phase series motor at the Westinghouse works in the early 90.'s, but that those experiments were probably not successful, as nothing more was heard of them. He believed, as did Mr. Steinmetz, that the repulsion motor would yet be brought to a commercially successful point and would be the alternating-current motor of the future.

Mr. B. G. Lamme, closing, emphasized that the motor he described is not a "proposed" motor, but one that had actually been built and tested on full commercial scale. Referring to the repulsion motor, he had considered that type, but rejected it in favor of the series motor, because of several disadvantages, such as its weight, the difficulties in the way of reversal, etc.

Regarding the question as to avoidance of sparking and the high-power factor, he said that no one factor could be named that was of special influence in securing them, but that the entire proportioning of the motor was involved. As to the relation between the power factor and the number of poles, he said that the latter was of little influence, that a 12-pole and a 4-pole motor would probably test about the same. A question had been asked as to the air gap; the air gap in the new motor was about the same as in similar direct-current motors. Other details, as to the winding, etc., he was not in a position to give at present.

A LARGE INSTALLATION OF AIR-COOLED SURFACE-CONDENSERS.

In the city of Kalgoorlie, West Australia, an electric central station has recently been built for furnishing power and lighting current to the neighboring gold mines. The three 1,500-HP. engines in this plant are provided with surface condensers cooled by air instead of water; this unusual type of apparatus was adopted because of the high cost of water in that region. The rainfall is less than 6 ins. per year, while the evaporation is very high. Water must, therefore, be obtained by pumping from wells, which yields a brackish supply, requiring distillation to make it suited for domestic use; large quantities of water are also shipped in by rail. A pipe line at present under construction—the famous Coolgardie pipe line—will, when completed, supply the cities of Coolgardie and Kalgoorlie with water from the Helena River, but the cost of water from this source will probably also be quite high.

The recovery of the condensation water from power plants is, therefore, an important matter.

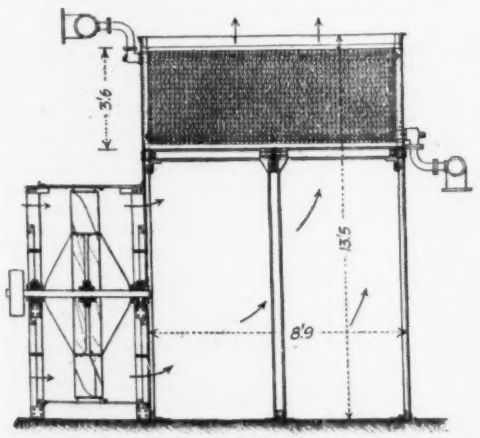


Fig. 1. Cross-Section of Air-Cooled Condenser. F. Fouche, Paris, France, Builder.

Ordinary methods of condensing the steam by means of water-cooled condensers are almost prohibitive in cost, particularly if cooling towers or similar devices be used, since these latter involve a loss of water about equivalent to the amount of condensation. In the present case of a 4,500-HP. plant, whose boilers require over 750 cu. ft. of water per hour, a continuous loss of even 10% of this amount would equal an expense of over $100 per day. In addition to the cost of water, however, the high fuel cost enters as a factor, rendering it desirable to secure the additional economy due to the use of condensing engines, operating only against condenser pressure.

For these reasons it was decided to adopt in the present case a form of condenser using an air-blast as the cooling medium. This type of condenser had already been tried in other, though

Fig. 2. View of Single Condensing Unit of Air-Cooled Condenser.

much smaller, power plants in Australia, where the conditions were similar to those at Kalgoorlie. The accompanying illustrations, from the "Schweizerische Bauzeitung," make clear the principal constructional features of the condensers installed.

Fig. 1 is a cross-section through one of the condensers. A plate-iron case open at the top is fitted with a fan, which forces a blast of air up through the case. At the top is seen the condenser proper, an aggregation of "units," through which the steam passes, and in which it is condensed. These units are of peculiar construction; they are composed of corrugated metal sheets (probably of some metal other than iron) joined in pairs by a steam-tight joint at their peripheries. Each such pair of joined plates forms a closed steam space in its interior, and between adjacent pairs is a space through which the cooling air passes. A number of the pairs of plates is joined into a unit by common steam inlet and water outlet pipes. One of the units is shown in Fig. 2.

A number of units are combined in a single condenser. The installation in question, intended to serve engines aggregating 4,500 HP., contains nine condensers; each condenser measures 25 ft. 3 ins. by 8 ft. 11 ins. in plan, and is supplied with air by three fanwheels. The fanwheels are about 7 ft. in diameter, and run at 300 r. p. m. The power consumption of these fans is not stated separately, but together with the air pumps they require about 120 HP., or 2.7% of the total power output of the plant.

As to the vacuum produced by the condensers it may be noted that the contract under which they were furnished called for specified degrees of vacuum varying from 21 ins. to 10 ins. for temperatures of air ranging from 50° F. to 97° F. This vacuum is likely to be exceeded in practice because of the fact that during the day, when the external temperature is highest, the load on the engines will generally be well below the maximum.

The installation of air condensers described is in the plant of the Kalgoorlie Electric Power & Lighting Corporation, Ltd. The engineers for the company were Messrs. J. G. White & Co., of New York and London; Mr. F. Fouché, of Paris, France, supplied the condensers, which are a patented invention controlled by him. A number of these condensers were shown at the Paris Exposition two years ago.

LAYING PIPE UNDER WATER AND SUBMERGED SUCTION MAINS.*

By A. L. Holmes.†

Perhaps there is no more perplexing condition presenting itself to a water-works manager or superintendent than a deep stream which it is necessary to cross with his main. On land he can carefully inspect and observe every detail of pipe-laying, and see that the specifications in regard to tamping and backfilling are rigidly complied with, but when he lays a line under water he must rely upon the honesty and sense of feeling of the diver. Encased in brass and rubber, weighted with a hundred or more pounds of lead, living in compressed air, and seeing at the best in clear water as one sees as in moonlight, it is only natural that diver's work is not always reliable.

Many of the faults and the faulty work done by the diver and much of the time consumed could be excused if we tried to realize the difficulties under which he labors in trying to repair leaks and broken pipes at the bottom of streams single handed, when if he tried to do the same work on the ground above water he would have a hard task if encased in the same suit.

About the only safe way for laying pressure pipes across navigable streams is to place them in a trench well below the bottom of the river, and pipe carefully laid in this way will give no trouble. If the bottom is soft there is little trouble in dredging a trench. If it is rock, it can be drilled and blasted from the surface and the loose rock cleaned out of the trench, the most of it from above, but it will pay to send a diver down to be sure of a clean channel before sinking the pipe.

In some localities with soft bottoms it has been a custom to lay the pipe on the mud with the upper ends disconnected and then by a sand pump working along the line of pipe gradually work it down to place. Where this can be done in sand or mud, the pipe will keep in the bottom of the trench and thus save the handling of some material. At Michigan City, Ind., a 20-in. force main across the harbor was lowered from a depth of 16 ft. 5 ins. to a depth of 20 ft. by the use of a sand pump and without any repairs whatever. This pipe was 100 ft. long and was fitted with five ball joints, and together with 1,200 ft. of other pipe on shore showed a leakage under 100 lbs. of water pressure of only 168 gallons in 24 hours. A 16-in. riveted pipe across the stream at Hammond, Ind., was lowered in this way by the use of a water jet and was perfectly tight when lowered. Of course, I do not advocate this way of doing the work where it is practicable to get and to maintain a trench otherwise, but some streams are so swift and carry so much fine sand or silt that the trench would fill as fast as dug.

My preference for submerged pipe is cast-iron hub and spigot pipe, with lead joints and every 36 or 48 ft. a flexible joint that will allow of considerable movement. The Ward joint is perhaps as well known in this country as any of the various forms and was for quite a number of years the only one. During the last 20 years half a dozen others have come on the market and the price has been largely reduced. Originally in using the Ward joint, which is made in the end of 12-ft. lengths of cast-iron pipe, it was the custom to use such joints on the whole line of submerged pipe, but this was not necessary and incurred a needless expense.

Wrought-iron pipe is used to a large extent by private concerns and there is a sufficient spring to a 6-in. wrought pipe with severed joints to conform to a surface that is quite uneven. A flanged cast-iron pipe for this work will be expensive to lay and probably cause trouble from leaks. With medium sized pipe, say up to 12 ins. diameter, the work of jointing and getting in place can be done above water. In one case under the writer's charge a line about 200 ft. long was sunk in 20 ft. of water, being lowered from the sides of scows by ropes. It showed no leaks at the time, neither has it in the 18 years since it was placed.

Of course many, or the most of these submerged pipe lines, do leak unknown to the water-works managers, and the best way to ascertain the amount of the leakage is by placing a valve at each side of a river crossing with a by-pass around it in which to place a meter. With the valves closed and a pressure on the meter the leak can be measured quickly. To locate the leak, I have found the use of an air pump the most efficient and the quickest means. With the valves closed and the air under pressure introduced into the submerged pipe, the air bubbles coming to the surface will locate the leaky joints very quickly.

In many streams in the interior, where there is no interference by boats, pipes are jointed on a frame of timbers sloping towards the stream, and as each length is added the pipe is launched into the water. The outer end is supported by floats, and as the pipe goes out floats are added about every 24 ft., until the whole line is put together, and it is then gradually lowered by long screws or ropes to the bottom. Cast-iron 12-in. pipe can be handled in this manner for about $1 per ft., including the lead used for joints, and it will cost about as much for the smaller sizes and but little more for 16-in. pipe. In some small streams, and moderate depth of water, I have used benches built of timbers, set in the ground or bottom of the stream, putting the pipe together on these platforms. It is easily lowered to the bottom, and I have personal knowledge of many lines that have been laid in this manner and have given no trouble.

The laying of pipe in cofferdams enables good work to be done, but it is generally very expensive.

In laying 24, 30 and 36-in. pipe in deep water, I have connected 40-ft. lengths, with lead joints in the usual manner, placing on each end of this section half of a bolted ball joint, and lowering this into the trench prepared for it, holding one end off the bottom with a piece of wood 8 × 8 ins. placed under the hub as the pipe was lowered to place. The next section prepared in the same way is lowered to place, and while in the slings and held just clear of the bottom the diver enters the ball into the bell

*Abstract of a paper read at the convention of the Central States Water-Works Association at Indianapolis, Ind., Sept. 24.

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and bolts it up. Pipe can often be laid in this way at the rate of 500 ft. per day.

Bulkheads are placed over the ends of the pipes before they are placed in the water to exclude fish and rubbish while lowering, and are removed by the diver and sent up for use again. It is not necessary to keep pipe absolutely in line. If it zig-zags a little it may keep tighter if it settles. In river crossings, a curve up-stream is generally desirable, so that as the current washes out under it and it works down stream it will become tighter.

At the end of suction pipes in lakes, I advocate the submerged crib or intake, and in most cases I believe wood for this purpose is cheaper and preferable. In the Great Lakes, where there is navigation, I should advocate placing the outer end of the intake in 40, or preferably 50, ft. of water. There is much less danger of obstruction to the water supply if a submerged crib is used than if it reaches above the surface. A crib of timber 24 ft. square and 8 ft. high, with a timber bottom and pockets loaded with stone (if no piles are necessary), can be placed for about $1,200.

Just as efficient protection is furnished by an upturned elbow on the end of the pipe, in which is inserted a tee of the same size; the ends of this are barred, leaving openings about 3 ins. wide. Around this drive 12 piles 10 ft. in the bottom and cut them off 2 ft. above the top of elbow; place riprap about this to the top of the casting and it is as safe as a more expensive construction.

All intakes and suction pipes for large plants should terminate in a reservoir or pumpwell on shore, to which the water should flow; and while pipes should be so planned that the pumps can operate directly on the intake, yet it is better that the pumpwell or reservoir have screens to shut out all foreign matter and that they be large enough to allow sedimentation to take place. All intake pipes should have valves placed at the outer ends and near the well, with provision for closing both and testing, under pressure through a meter, for leaks and with air to locate them.

Leaky suctions, whether on shore or under water, are the terror of the engineer at the pumping station, reducing the efficiency of the machinery and ruining the engines. A little care and persistency will find and stop the leaky pipes, and save annoyance and coal bills. All suction and intake pipes should, of course, be laid to such a grade that air pockets may be avoided. Where suctions are partly above the water line (as in driven well connections), and are very long, in many cases it has proved advantageous to install an air or vacuum pump to remove the air that comes in from many leaking joints.

I once removed an intake at Negaunee, Mich., laid ten years before in the bed of a muddy lake, the outer end in 30 ft. of water. It was found that in laying the pipe it had broken in five places and for ten years it had sucked in the disease-breeding filth about 100 ft. from shore, instead of getting the purer water through the 1,200 ft. of pipe as intended. The experience at Duluth, a few years ago, where the intake was discovered broken in several places, and where typhoid was rampant evidently from this cause, is another instance. Neither of these accidents could have happened if provision had been made for testing the main for leaks as advocated above.

A plant taking water from wells across a small pond from their pumping station sunk a line of spiral riveted pipe for a suction and could not lower the wells at all, but an outbreak of typhoid and an investigation and analysis of the water, disclosed the fact that the water in town was identical with that in the filthy pond and entirely unlike the well water. Upon taking up this pipe, a connection was not only found through a tee with a check valve a few feet from shore, but several lengths of the pipe had let go or unwound, and the reason for the sickness and deaths was disclosed.

If the water-works managers will look after these underwater force mains, they will in many cases find where a lot of the water they pump goes to; and if they will test their suction pipes going out to good water they will find them sucking in the filth and dangerous poisons in the mud near shore and will find the reason for a good many disease germs found in water taken from the faucets when an analysis of the water at the intake shows nothing of the sort.

Many cases of well supply, ample for domestic service, are supplemented by a dangerous supply to be used only in case of fire, and to be flushed out of the mains afterwards. How does any one know that the filthy water is removed? And how sure are we that a leaky valve or a careless engineman is not all the time mixing our drinks?

THE MANUFACTURE OF LOCOMOTIVES IN THE UNITED STATES DURING THE CENSUS YEAR.

The manufacture of locomotives in the United States during the census year 1900 is reported upon in a bulletin recently issued by the Census Bureau. The report is made by Mr. Edward H. Sanborn, Special Expert Agent, and includes locomotives of all kinds, traction engines and automobiles. Referring to locomotives alone here the report shows that during the year 1900 there were 28 establishments, the sole or chief product of which was locomotives. These 28 establishments made during the year 2,774 locomotives of all classes valued at $27,121,063. To these figures are to be added 272 locomotives valued at $3,276,393 constructed at 26 railway shops. The total was thus 3,046 locomotives valued at $30,397,456. In 1890 there were 2,409 locomotives valued at $19,752,465, built at 19 establishments, exclusive of railway shops.

TABLE I.—Number and Value of Locomotives Built in Locomotive Works and Railroad Repair Shops, By States: 1900.

State.	Aggregate		Total.		Steam. Simple.		Steam. Compound.		Compressed air.		Electric.		Ga...	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	V...
Illinois	80	$438,101	67	$420,601	67	$420,601	...	.....	..	.....	8	$12,500	5	$5...
Michigan	16	107,011	16	107,011	16	107,011	...	.....	..	.....	..	.....	..	....
New York ...	743	8,578,399	718	8,540,899	670	7,933,757	48	$607,142	25	$37,500	..	.....	..	....
Ohio	113	263,474	33	113,474	33	113,474	..	.....	..	.....	80	$150,000	..	....
Pennsylvania .	1,502	15,736,320	1,465	15,532,447	1,219	12,504,981	246	3,027,466	30	78,302	67	125,571	..	....
Virginia	121	1,165,920	121	1,165,920	93	896,400	28	269,520	..	.....	..	.....	..	....
Other states*..	411	4,108,231	411	4,108,231	404	4,024,314	7	83,917	..	.....	..	.....	..	....
The U. S...	3,046	$30,397,456	2,831	$29,988,583	2,502	$26,000,538	329	$3,988,045	55	$115,802	155	$288,071	5	$5,...

*Includes Alabama, 26; Arkansas, 3; Connecticut, 6; Indiana, 1; Iowa, 8; Kansas, 12; Maryland, 2; Missou... 2; New Hampshire, 33; New Jersey, 263; North Carolina, 3; Rhode Island, 29; Texas, 9; Vermont, 1; Wisconsin, 1...

The statistics show that there was a considerable increase in the value of locomotives built in 1900 as compared with 1890. The 2,409 locomotives built in 1890 had an average value of $8,199, while the 2,774 built at locomotive works in 1900 had an average value of $9,777, being an increase of $1,578, or 19.2%. The increase in number of locomotives built during 1900, as compared with 1890, appears to have been due to the increased foreign demand, there having been 525 locomotives exported in 1900 as compared with 191 in 1890. Table I. shows the number and value of locomotives built in 1900 by states, type, class, etc. It will be noted that included among the locomotives built in 1900 there were five mine locomotives operated by gas. The figures of 1900 also included 17 miniature locomotives and 63 geared locomotives, valued at $247,813. Of the 55 compressed air locomotives nearly all were for mine traction and were simple engines. The electric locomotives were also mostly mine engines, operated from a central station, but there were a few equipped with storage batteries. Electric locomotives are built for the most part by steam locomotive establishments, which purchase the motors and their attachments.

BOOK REVIEWS.

THE VENTILATION OF THE SCHOOL ROOM.—By Wm J. Baldwin, M. Am. Soc. C. E., M. Am. Soc. M. E. New York: The Author. Cloth; 5 × 7 ins.; pp. 46; seven plates. $1.

This is a somewhat popular, but none the less valuable, presentation of the author's ideas, and presumably his practice, in the matter of school ventilation. All but one of the illustrations are colored plans and sections designed to show the movement of air in buildings.

THE MANUAL OF STATISTICS.—Stock Exchange Hand-Book, 1902. Railroads, Street Railways, Industrials, Government Securities, Stock Exchange Quotations, Mining, Grain and Provisions, Cotton, Money, Banks and Trust Companies. New York: The Manual of Statistics Co. Cloth; 5½ × 8 ins.; pp. 912; 34 maps. $5.

The purpose of this volume is very well indicated by its sub-title, "Stock Exchange Hand-Book," and it certainly contains a mass of information useful from that point of view. The facts relating to corporations are grouped under railroads, street railways and industrials. The latter heading includes a number of street railway, lighting and power systems working in combination, perhaps most of the principal independent lighting companies of the country, and a few water-works companies. Under each company a brief history is given, together with the property which it controls, a summary of its financial statistics, its chief officials and directors. The other features need no comment here.

KONSTRUKTIONSTAFELN FUR DEN DYNAMOBAU.—Edited by Prof. E. Arnold, Director of the Electrotechnical Institute of the Carlsruhe Technical College. Part I., Gleichstrom-maschinen: Portfolio of 60 plates, 38 × 50 cm. (about 15¼ × 20 ins.). Part II., Wechselstrom-maschinen: Portfolio of 60 plates, 38 × 50 cm. Stuttgart: Ferdinand Enke. Price of each part, 20 M. 40 pf.

As the above indicates, this is a collection of plates of electrical machines (mainly generators) and their detail parts. It may be looked on as a complete exposition of continental European practice, and as such should be of much interest to the American electrical engineer. The second part, dealing with alternating-current machines, is probably more important in this sense than the first, though here the numerical data given are at best scant and in many cases are almost entirely lacking. Part I. gives drawings of 41 machines of a capacity from 3.5 to 1,000 KW. The drawings in Part II. cover 29 generators and synchronous motors of capacity from 20 to 1... KW., 4 motor generators, 5 rotary converters of capacities from 150 to 500 KW., 8 transformers and 13 induction motors. It may be noted that in this part are included two American machines, a 1,500-KW. Westinghouse two-phase alternator, and a 1-KW. single-phase motor of the Wagner Electric Co., St. Louis, Mo.

AMERICAN STREET RAILWAY INVESTMENTS. A Supplement to the Street Railway Journal. Published Annually for the Use of Bankers, Brokers, Capitalists, Investors and Street Railway Companies. New York: The Street Railway Publishing Co. Cloth; 10 × 13 ins.; pp. 306; 31 folding maps. $5.

This volume contains descriptions of the road and equipment of 1,281 street railway companies, summaries of their financial features and traffic statistics, and the names and addresses of the officers and directors of the several companies. Brief histories of the companies, with dates of charters and municipal franchises, are also given. The maps are a handy and valuable feature of the book, particularly those showing interurban lines. A "Review of the Year" sets forth some of the most interesting features of street railway activities in nine of the larger cities of the country, and is followed by a comparison of the gross receipts for 1900 and 1901 of 246 companies having gross annual incomes of $25,000 a year or over. The figures show an increase of 9.3% for 1901.

THE BEAUMONT OIL FIELD.*

By Robert T. Hill.†

Before the first white man came, it was known that oil existed in small quantities in western Louisiana and Texas, within 100 miles, more or less, of the present site of Beaumont. It was a matter of rumor for many years that oil floated upon the sea just west of Port Sabine. Petroleum springs existed at several places, notably Lake Charles, Louisiana. It had also been encountered in the well-borings in western Louisiana, east of Beaumont. As early as 1862, unprofitable attempts at drilling had been made at Sour Lake. Even at Beaumont, similar attempts failed. Until 1901, no man had obtained the oil in commercial quantities.

The finding of oil at Beaumont was not an accident, but, like all other great discoveries, the dramatic culmination of long and extensive research and many experiments, each of which was an important factor in the final result. Capt. A. F. Lucas, to whom the glory of the crowning achievement is fairly due, had been, since 1892, carefully studying the geology of the coastal plain of western Louisiana and eastern Texas, with the view of developing its salt, sulphur and petroleum. With the aid of every recorded observation which he could obtain, supplemented by his own experience and reasoning, he concluded that the structure and stratigraphy of Beaumont gave the best prospect of oil. Previous failures at this place were, in his judgment, due to mechanical difficulties, which could be overcome—an opinion which he fully confirmed by his work.

Capt. Lucas is a native of Austria and a graduate of the Polytechnic School of Gratz and of the Imperial Austrian naval school. He had been for some ten years actively engaged in this country as a mining engineer, especially in the development and operation of the salt mines of Louisiana.

In connection with this work, he found in one or two places indications of oil, and also of sulphur (of the existence of which, in that region, the famous Calcasieu deposit is a proof). Conceiving the plan of a systematic exploration for oil, he finally chose Beaumont, Tex., as the scene of operations. His first well, begun in 1899, was 575 ft. deep in March, 1900, and showed a trace of oil at the bottom, when the casing broke, and the well had to be abandoned. Not daunted, he commenced in October, 1900, another well beside the old one. The public will never realize the obstacles and difficulties which had to be overcome. One of Capt. Lucas's greatest technical achievements was the putting of a drill hole through 1,100 ft. of clay and quicksand. The methods and contrivances used by him made possible the other wells which have followed. This second well, which "came in" Jan. 19, 1901, was the famous "Lucas Gusher."

ECONOMIC CONDITIONS.—The Beaumont oil, when

*Extract from a paper on "The Beaumont Oil Field with Notes on Other Oil Fields of the Texas Region," read before the American Institute of Mining Engineers.

†U. S. Geological Survey, Washington, D. C.

first discovered, was found to be of a different quality from that of any other field, and many doubts arose as to its value and uses. Having a heavy base of asphaltum, and being thoroughly impregnated with sulphur, it was supposed to have no value as an illuminant, and many believed that the excess of sulphur would so corrode boilers that it could not be used as a fuel. This sulphur was so apparent that on occasions, as on March 4, 1902, it filled the atmosphere, leaving a coating of sulphur on many of the houses in Beaumont, some 3 miles from the oil field.

The composition of the oil from chemical analyses by Prof. F. C. Thiele is as follows:

I.

	Per cent.
Kerosene	36.00
Light lubricating oil	21.05
Medium lubricating oil	21.05
Heavy lubricating oil	10.52
Asphalt	6.34
Loss and gases, including sulphur	5.04
	100.00

Color of crude oil: brown, opaque.
Sp. Grav., 0.9206; equivalent to 22° B. at 65.57° F.

II.

Naphtha	6.45
Kerosene	35.00
Lubricating oil	43.90
Residue and gases	14.65
	100.00

Test of obtained kerosene:

Color	Prime white.
Sp. Grav	0.872, equivalent to 30° B at 65.5° F.
Flash-point	120° F.
Fire-test	150° F.

It was soon realized that, if fit for no other uses, this was an excellent fuel. After a year of experiment, it is now generally conceded that the oil has many excellent qualities, and that, after refining for the kerosenes, the remainder is as good a fuel and gas-making material as can be desired. Upon the basis of elaborate refinery, chemical and fuel tests, made on large quantities, the following facts may be stated as established: (1) The Beaumont oil has a low flash-point of 120° F., which renders it an unsafe, or at least undesirable, cargo in tank ships; (2) refined by first distillation, it produces 30% of export illuminating oil, leaving a residuum of good fuel oil, which can be transported with perfect safety; (3) the sulphur can be extracted if necessary, but when left in the oil has no injurious effect whatever upon the boilers, while it adds to the fuel value; (4) as a fuel, three barrels of this oil can be delivered by rail in any city in Texas at a price of $2.70, the price of bituminous coal being $5, and that of anthracite coal $10 per ton. The oil may be laid down in New York, Philadelphia or Boston at 75 cts. a barrel.

Immediately after the discovery at Spindle Top every acre within 50 miles was leased, and wells were started everywhere. Since it then took from three to six months to put down one of these costly wells, some time was required to show by experiment that all the oil in the immediate vicinity of Beaumont was confined to Spindle Top hill, within an area of less than 300 acres.*

This was at first seriously discouraging. Many thought that if the oil was confined to this one small locality it would soon be exhausted, and the business would be at an end. Prudent operators at Spindle Top did not feel justified in making long-time contracts; and railways and factories, with the risk of an exhausted supply before them, naturally hesitated to make the expensive changes required for the use of this fuel.

The "coming in" of Jennings, Sour Lake and Saratoga removed the fear of inadequate supply; and no one apprehends an early cessation of production, even if Spindle Top should be exhausted, which has not been proved probable.

When the Beaumont well was discovered, the writer, aware that similar conditions existed over a wide area, ventured the following prophecy:

> It is entirely within the limit of probability that oil will be found at many places throughout the Coastal Prairie, especially in its southern extension toward the Rio Grande and in the northeastern State of Mexico at Tamaulipas. The outcrop of the Tertiary formations in southwest Texas, in Wilson, Atascosa, McMullen, Duval and other counties, is naturally rich in oil; and the practical oil men are risking their money in experimenting in this region. As the oil-bearing Tertiary strata extend east of the Mississippi into Mississippi and Alabama, it is not beyond possibility that oil may be found in these States.

The following data, showing the results of one year's exploitation, sufficiently confirm this declaration, which was received at that time with incredulity:

At Jennings, Louisiana, 150 miles east of Beaumont, a good flow of oil has been encountered. This well is 1,830 ft. deep, and is described as a mild sort of "gusher." In the morning it spouts about 35 ft., and at other times just high enough to make a good flow. Although this oil is accompanied by a great deal of sand which chokes up the well, it demonstrates the broad geological fact which I asserted. Practical oil men have such faith in the locality that a dozen or more well rigs are at work. The sand problem is a mechanical difficulty which all are confident will be overcome.

Proceeding west from Jennings toward Beaumont, oil has been found in varying quantities at Lake Charles, near Crowley, and in one or two other places.

At Sour Lake, 25 miles northwest of Beaumont, oil has been known to exist since 1862, and a dozen years ago many pumping wells were operated, and a small refinery was established. The field was abandoned, but after the Beaumont discovery numerous well rigs were set up to penetrate to greater depths. From seven to eleven different oil strata were passed through, and in August, 1901, a well, similar to that at Jennings, was obtained by the Guffey people. Its product has not been reported.

On March 7, 1902, another great oil strike was made at Sour Lake, at a depth of 685 ft., by the Atlantic & Pacific Co. It is said that the oil shot 150 ft. into the air, and was of better quality than that at Beaumont.

Twelve miles north of Sour Lake, at the village of Saratoga, where the oil outcrops at the surface as maltha, it is said that a good oil well has been obtained, flowing several thousand barrels per day.

Rockland, north of Saratoga, is the next place where oil deposits are found, and experimental boring has been going on here for some time. The sand rock near the surface is completely impregnated with oil.

Between Sour Lake and Houston, 50 miles farther west, many experiments are in progress, but no success has been reported. In the city of Houston, I am informed by Major Cave, of the Houston & Texas Central Ry., that a small flow of oil had come from his well for many years.

Fifty miles south of Houston, near the mouth of the Brazos River, in Brazoria county, there is a field which, according to Capt. Lucas and the geological evidence which we possess, gives excellent indications for oil. There are no less than fourteen expensive well rigs set up in this and Brazoria county, four of which were upon the remarkable hill known as Damon's Mound, one or two at Big Hill, and one at Keyser's Mound.

The wells on Damon's Mound encountered small flows of oil at depths of from 400 to 600 ft., exactly as at Beaumont, but so far they have been unsuccessful in securing a commercial flow.

At Keyser's Mound, in the same county, about 6 miles north of Damon's, and near the Brazos River, a flow of oil was struck at about 400 ft., but unfortunately the drillers were unable to cut off a tremendous flow of artesian water which was encountered just above it, and, as a result, the well produces to-day a remarkable emulsion of oil and water.

The well at Velasco (Bryan Heights) struck, at about 600 ft., a flow of gas so violent that its roar could be heard for miles. As a gas well, this was as remarkable a phenomenon as were the Spindle Top oil "gushers." The flow of gas could never be controlled; the well had to be abandoned, and a new hole, started beside the old one, is now giving every indication of securing oil.

Proceeding southward throughout the vast desert of the Lower Rio Grande, small quantities of oil have been encountered at several places, while still farther southward, at the end of our Coastal Plain, some miles from Beaumont, authentic reports have recently been received that flowing wells have been developed at Tampico, Mexico. Even as far south as the State of Tobasco two flowing wells are reported. These results of a single year, although still fragmentary, are sufficient to reinforce our belief that in the future years the Beaumont field will furnish other profitable localities of commericial oil besides Spindle Top.

A YEAR'S DEVELOPMENT.—On Jan. 10, 1902, one year from the date of the discovery of oil, there were 136 wells on Spindle Top. Operations for the first three months of the second year show a great increase; the number of "gushers" has grown from 136 to 214, and more wells are drilling at present than at any previous time.

Three pipe lines have been finished, two to Port Arthur (19 miles) and one to Sabine (24 miles). Pipe lines from Beaumont to New Orleans, and Beaumont to Galveston, Houston and other Texas points, are contemplated.

On March 1 the tank storage exceeded 5,000,000 barrels. Among the tanks of 37,500-bbl. capacity and over were 22 at El Vista, 28 at Gladys and 33 at Port Arthur.

The demand for tank cars has constantly increased. In February, 1902, 500 cars were added, making a total at that time of 1,500. The Southern Pacific Ry. has since purchased 250 tank cars of 12,850 gallons capacity each, and many of the cars have already arrived at the loading racks. Many companies now have ample shipping facilities. In addition to the regular tank-car lines, there are between 800 and 1,000 tank cars owned by local oil companies. A huge tank-car factory is being erected at Beaumont to supply the demand.

Tank steamers also have been in great demand. Many ships have cleared from Port Arthur, but the supply nowhere approximates the demand. The Guffey Co. is constructing five steamers, one of which, to carry 60,000 bbls., is the largest ever made in America, and will equal any in the world.

The Guffey Co. already has two refineries completed at Port Arthur, and another approaching completion. Work on five other refineries is progressing rapidly. Guffey Refinery No. 3, at Port Arthur, will have a capacity of 2,500 barrels per day. This company will ship no crude oil, but will bring the flash-point up from 120° to 145° and 150°, by taking out naphtha and kerosene, before shipment.

Within a year from its discovery, Beaumont oil is burning in Germany, England, Cuba, Mexico, New York and Philadelphia. By its energy steamers are being propelled across the ocean, trains are hastening across the continent, electricity is generated and artificial ice frozen in New York, ores are ground and stamped in Mexico, Portland cement is manufactured in Havana and Texas, and gas enriched in Philadelphia; and this, too, while half the world is either unaware or incredulous of the value of this fuel.

A strong demand for the oil comes from the manufacturers of illuminating gas. In March, this demand from New York and Philadelphia was great enough to justify a daily steamer from Port Arthur to those cities. The oil is also being sent to Atlanta and other cities for this purpose.

Many of the great railway lines of Texas have changed or prepared to change from coal to oil as fuel for their locomotives. The oil is also being used in hundreds of small factories in Texas, such as breweries, brickyards, etc. Even the farmers are using it as a fuel sufficiently inexpensive to permit of pumping for irrigation.

The production of the Beaumont oil field during its first year was limited for the lack of means of distribution. It is estimated, however, that 5,500,000 barrels were actually drawn from the great reservoir—one-half of which was stored in tanks and the remainder consumed, shipped or wasted.

The shipments for 1901 were 1,750,000 bbls.; for the first three months of 1902 they exceeded that total, those for March alone being more than 800,000 bbls. The field will probably ship 20,000,000 bbls. in 1902.

It is estimated that the development of this field has cost $7,000,000, of which about $1,250,000 has been paid for labor. The tubing and well-drill rigs have cost, approximately, another million. Pipe lines, lumber for derricks, and tanks for storing the oil have consumed the remainder.

The average cost of sinking a well at Spindle Top is $7,249. The 215 wells that are "in," together with the adjacent "dusters," have cost fully $2,000,000. Probably $50,000,000 more has been expended for purchase of land, transportation facilities and other legitimate purposes. The capitalization of the 200 companies in the field is placed at $200,000,000.

Before Capt. Lucas's well came in, land could be purchased anywhere in the Coast Prairie country for less than $4 an acre. Millions of acres have since changed hands at fabulous prices, while every foot has been leased for favorable considerations. Thousands of acres of this land 150 miles from Beaumont have sold for as much at $1,000 per acre. Land within the proved field has sold for nearly $1,000,000 an acre, $900,000 having recently been paid for one acre. No sales were made for less than $200,000 per acre. Spindle Top to-day may be justly assessed at a valuation of $500,000 an acre, or $100,000,000. Two years ago it could have been bought for less than $10 an acre.

The 214 wells upon the field are owned by about one hundred companies. It is estimated that 120 of the wells are located upon 15 of the 200 acres of productive territory. These wells are in the hands of nearly as many individual companies, mostly small organizations without means for operation or facilities for outlet and transportation. The remainder of the territory is within the hands of four or five legitimate operators, who not only possess wells, but tank cars, pipe lines, refineries, etc., for handling and marketing the oil.

*The exact extent of the productive ground of Spindle Top hill has not yet been determined, because several of the largest corporations own large tracts on one side of the hill, where the limits have not been exploited. It is known that this field certainly exceeds 200 acres, and most of the oil men think it will reach 300 or 325 acres. It is still occasionally widened by new wells.

THE PREVENTION OF ELECTROLYSIS OF GAS AND WATER PIPES IN GREAT BRITAIN.

An interesting and apparently comprehensive review of steps taken to prevent electrolysis in Great Britain was presented at the recent meeting of the British Association of Water-Works Engineers by Mr. W. H. Humphreys, Water-Works Engineer of York, England.

In 1893, the Board of Trade asked Parliament to establish uniform regulations protecting telegraph and telephone systems from high-tension currents of lighting and traction works. A committee of both houses, presided over by Lord Cross, was appointed to consider the matter. The manner in which the attention of this committee was diverted from wires to pipes is thus described by Mr. Humphreys:

> It was not until Sir Courtenay Boyle, the permanent secretary of the Board of Trade, startled the committee and

alarmed the gas and water authorities by his evidence, that they became aware of the danger of electrolysis. He mentioned an instance where gas and water pipes were eaten away by "arcing," and a very serious accident was narrowly averted. This "arcing," however, as afterwards explained by Major Cardew, who had very thoroughly examined into the phenomena, was caused by the current supplying an electric light being deflected to a lead pipe and fusing it. The committee were further impressed when shortly afterwards Sir W. H. Preece (then Mr. Preece) told them that he was anxious that they should appreciate the question of voltage, and he went on to explain that

this electrical pressure formed between gas and water pipes is by far the most serious disturbance that is likely to be brought to your notice. The effect of it, if not checked, would be that the water pipes or the gas pipes, whichever was connected with the positive side of the current, would in course of time become decomposed; the constant action of the current on pipes covered with moisture, when it exceeds a certain voltage, means electrolytic decomposition, and unless some steps were taken to prevent this, then there certainly will be leakage of gas or water and possibly accident.

Evidence of this nature, coming from such an authority, did not fail to impress the committee; moreover, Lord Kelvin also spoke strongly against powerful currents being allowed an earth return as being fatal to gas and water pipes. The result was that the committee decided to hear counsel on behalf of the gas and water companies. With the conclusions of Mr. Preece and Lord Kelvin Dr. Hopkinson agreed; but Mr. Crompton, Major-General Webber, and other noted electrical experts, thought that the question of electrolysis due to leakage from continuous currents had been either non-existent, over-estimated, or exaggerated. Major Cardew, the electrical adviser of the Board of Trade, produced for the inspection of the committee a piece of lead water pipe, very much corroded throughout, and showing that where there had been a weak place in the lead, a hole was eventually formed; he had no hesitation in stating that "the greater part of the corrosion, and the rapid nature of it, was due to electric current." He had, further, made an interesting calculation as to the amount of metal corroded by a given current in a given time; for a continually flowing current of 1 ampere it would, he said, take five days to eat away 1 lb. of lead, 16¼ days to eat away 1 lb. of copper, and 27 days to eat away 1 lb. of iron. Professor Dewar raised the question in another form—namely, that it was not a question of specific electrolytic action on the pipe itself; but it was a graver question, as to how far the additional cause of corrosion, added to natural causes of corrosion, would accelerate the destruction of the pipe, and that the whole danger was preventable.

The water-works interests attempted to induce the committee to recommend very stringent rules for the prevention of electrolysis, including the prohibition: (1) Of uninsulated conductors "for carrying any supply of electricity from or to the generating station;" (2) of using the earth for return circuits; (3) using gas or water mains for the same purpose. The water-works interests also sought to make electric corporations subject to legal action and damages for injury caused by their currents. The parliamentary committee did not agree to these conditions, but it suggested certain guarded regulations for insertion in parliamentary bills and orders and recommended that the Board of Trade be authorized to make "regulations to secure the best system of construction."

ELECTROLYSIS REGULATIONS OF THE BRITISH BOARD OF TRADE.

The regulations finally issued by the Board of Trade required the insulation of conductors (or "line") between generators and motors, and permitted the use of uninsulated return wires, under the following conditions:

(5) When any part of a return is uninsulated it shall be connected with the negative terminal of the generator, and in such case the negative terminal of the generator shall also be directly connected, through the current indicator hereinafter mentioned, to two separate earth connections which shall be placed not less than 20 yds. apart. Provided that in place of such two earth connections the company may make one connection to a main for water supply of not less than 3-in. internal diameter, with the consent of the owner thereof and of the person supplying the water, and provided that where, from the nature of the soil or for other reasons, the company can show to the satisfaction of an inspecting officer of the Board of Trade that the earth connections herein specified cannot be constructed and maintained without undue expense the provision of this regulation shall not apply. The earth connections referred to in this regulation shall be constructed, laid, and maintained so as to secure electrical contact with the general mass of earth, and so that an E.M.F. not exceeding 4 volts shall suffice to produce a current of at least two amperes from one earth connection to the other through the earth, and a test shall be made at least once in every month to ascertain whether this requirement is complied with. No portion of either earth connection shall be placed within 6 ft. of any pipe, except a main for water supply of not less than 3 ins. internal diameter, which is metallically connected to the earth connections with the consent hereinbefore specified.

(6) When the return is partly or entirely uninsulated, the company shall, in the construction and maintenance of the tramway (a) so separate the uninsulated return from the general mass of earth, and from any pipe in the vicinity; (b) so connect together the several lengths of the rails; (c) adopt such means for reducing the difference produced by the current between the potential of the uninsulated return at any one point and the potential of the uninsulated return at any other point; and (d) so maintain the efficiency of the earth connections specified in the preceding regulations as to fulfil the following conditions, viz.: (i.) that the current passing from the earth connections through the indicator to the generator shall not at any time exceed either 2 amperes per mile of single tramway line or 5% of the total current output of the station; (ii.) that if at any time and at any place a test be made by connecting a galvanometer or other current indicator to the uninsulated return and to any pipe in the vicinity, it shall always be possible to reverse the direction of any current indicated by interposing a battery of three Leclanché cells connected in series if the direction of the current is from the return to the pipe, or by interposing one Leclanché cell if the direction of the current is from the pipe to the return. In order to provide a continuous indication that the condition (i.) is complied with, the company shall place in a conspicuous position a suitable, properly connected, and correctly marked current indicator, and shall keep it connected during the whole time that the line is charged. The owner of any such pipe may require the company to permit him at reasonable times and intervals to ascertain by test that the conditions specified in (ii.) are complied with as regards his pipe.

(7) When the return is partly or entirely uninsulated a continuous record shall be kept by the company of the difference of potential during the working of the tramway between the points of the uninsulated return furthest from and nearest to the generating station. If at any time such difference of potential exceeds the limit of seven volts, the company shall take immediate steps to reduce it below that limit.

(8) Every electrical connection with any pipe shall be so arranged as to admit of easy examination, and shall be tested by the company at least once in every three months.

(9) Every line and every insulated return or part of a return except any feeder shall be constructed in sections not exceeding one-half of a mile in length, and means shall be provided for insulating each such section for purposes of testing.

(10) The insulation of the line and of the return when insulated, and of all feeders and other connectors, shall be so maintained that the leakage current shall not exceed one-hundredth of an ampere per mile of tramway. The leakage current shall be ascertained daily before and after the hours of running, when the line is fully charged. If at any time it should be found that the leakage current exceeds one-half of an ampere per mile of tramway, the leak shall be localized and removed as soon as practicable, and the running of the cars shall be stopped unless the leak is localized and removed within 24 hours. Provided, that where both line and return are placed within a conduit this regulation shall not apply.

The water interests were not satisfied with the Board of Trade regulations, which, they believed, actually protected the electric companies from all claims for damages, even when the rules were wilfully violated. After some agitation, which appears to have been futile as late as 1900, Parliament was at last induced to take further action, by inserting clauses "almost identical in expression," in a number of special acts or orders "providing for compensation for injury to mains by electrolytic action." The "Sheffield Clause," as this safeguard is termed, was not secured until "after a very stiff fight, and the usual conflict of opinion between expert witnesses." This clause is as follows:

Provided, that notwithstanding anything contained in the said Acts or this Act, if it be proved that any injury or damage to any mains, pipes, or apparatus of the Sheffield United Gaslight Co. shall have resulted from fusion or electrolytic action caused by any currents generated or used for the purpose of electric traction on any of the tramways for the time being belonging to the Corporation nothing in the said Acts or this Act shall relieve the Corporation from any liability to make compensation for such injury or damage which would have existed, but for the passing of the said Acts and this Act.

It is a mooted question in England and Scotland whether the Board of Trade safeguards against electrolysis are sufficient. Mr. Humphrey appears to have been unable to cite any serious damages from electrolysis, but this may be due quite as much to the very recent introduction of electric traction as to observance of the precautions prescribed above.

In the course of his paper Mr. Humphrey quotes from the proceedings of both the [illegible] England and the American Water-Works [illegible] ciations, including, as an appendix, the [illegible] (1900) of the special committee of the latter [illegible] ganization. We are indebted to "The Con[illegible] Journal" of July 30, for a copy of Mr. H[illegible] phrey's paper.

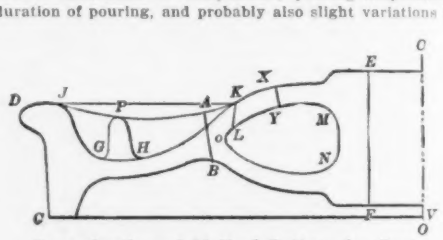
THE CALCULATION OF THE WEIGHT OF CASTINGS WITH THE AID OF THE PLANIMETER *

By C. M. Schwerin.†

The object of this graphic method is to estimate the weight of the casting, which is to be made from a given pattern, when the cross-section is not a uniform geometrical figure. Such an estimate is a very important guide to the foundryman, who would otherwise guess at the probable weight of a casting of new design, and, in trying to be on the safe side, would probably melt an unnecessary amount of iron. It is also an aid to the designer of a new car-wheel pattern, who must otherwise estimate from general experience the probable weight, have test-wheels made, and correct the pattern afterwards, so as to obtain the weight prescribed.

For the method here described, an accurate drawing of the pattern is employed. This gives a closer result than a drawing of the wheel itself, for the following reasons: (1) Calculations based upon the actual dimensions of the wheel involve the erroneous assumption that the specific gravity of the casting is uniform throughout; and upon that basis the calculated weight would be wrong, because the amount of metal poured has shrunk in the mold, acquiring the highest density in the outside chilled portion, and growing less dense through the mottled to the gray portions. (2) Calculations based upon the dimensions of the pattern or "chiller" assume that the cooled metal will not have shrunk, but will have the volume of the pattern and a uniform density.

These assumptions, though erroneous, counterbalance each other. For instance, the patterns and the chiller which give a wheel of 33 ins. in diameter when cold, are respectively 33.5 ins. in diameter. This shows a shrinkage for wheel-iron of about 3-16-in. (ordinary gray pig is commonly assumed to shrink about ⅛-in.) per ft. Wheels cast in 33.5-in. chillers do not always have the same diameter. They may vary ⅛-in. either way by reason of differences in composition, pouring-temperature, duration of pouring, and probably also slight variations in



Cross-Section of Half of Pattern for Cast-Iron Car Wheel.

(L M N, cross-section of pan core; G H P, cross-section of bracket; E F C D, cross-section of plates, tread and flange; J P K, top of bracket; J K, circle of rim; A O, center line of wheel axis.)

cooling. But the average diameter is 33 ins.; and it is found that a calculation based upon the 33.5-in. pattern, and the assumed uniform density of 0.26-lb. per cu. in. of molten wheel-iron, as it fills the mold, gives correct weights of the wheels, even though the latter vary in size, as before explained.

For a casting of uniform specific gravity, either the drawing of the casting, or that of the pattern, could be used. If the latter, then a percentage for shrinkage must be subtracted.

The accompanying cut shows half the cross-section of the pattern of an ordinary cast-iron car wheel. From the full-sized drawing, divided as shown in the figure, the areas A B C D and E F B A are taken with the planimeter, and the area L M N, similarly determined, is subtracted from their sum. The remainder is the area of the half-section of the pattern, exclusive of the brackets. Let this area in sq. ins. be called A.

A blue print is then made, pasted on cardboard, cut out along the lines D E F C D and L M N L, and then balanced on a pin-point, to determine the center of gravity of the irregular figure. This point (o in Fig. 1) is located on the tracing, and its distance from the center-line of the wheel-axis O o, is measured. Let this distance in inches be R. If w = 0.26-lb. be taken as the weight of the metal per cu. in., and W as the weight of the wheel, then $W = 2\pi R \times A \times w +$ weight of brackets and letters, minus weight of metal displaced by the core-legs of the pan-core.

The following calculation for two wheels is given as an example:

The calculation for $2\pi R \times A \times w$ was as follows:

*A paper read before the American Institute of Mining Engineers.

†Chicago, Ill.

	No. 1.	No. 2.
Area of E F G D	52.38 sq.ins.	53.17 sq.ins.
Area of L M N	12.42 "	9.60 "
Net area (A).....	39.96 sq.ins.	43.57 sq.ins.
R.....	9.38 ins.	9.25 ins.
Cu. contents* $2\pi R \times A$...	2,353.6 cu.ins.	2,531.0 cu.ins.
Weight (cu. cont. × 0.26)...	611.95 lbs.	658.0 lbs.

*Cubic contents of pattern.

The requisite addition for weight of brackets is approximately calculated as follows:

	No. 1.	No. 2.
Area G F H	2.24 sq.ins.	2.30 sq.ins.
Assumed average, ½ G.P.H.	1.12 "	1.15 "
Avg length meas. on curve	10.5 ins.	10.25 ins.
Volume of 1 bracket	11.8 cu.ins.	11.8 cu.ins.
Weight (volume × 0.26)....	3.06 lbs.	3.06 lbs.
Weight of 13 brackets.....	39.78 "	....
Weight of 15 brackets.....	....	45.9 lbs.

Note.—The 650-lb. wheels have 13, and the 700-lb. wheels 15, brackets.

The weight of the letters was obtained by weighing the same letters cast in lead, and taking seven-tenths of the result as correct for iron. This gave, for each wheel, 1.2 lbs.

The amount to be subtracted for the metal displaced by the core-legs was calculated as follows:

	No. 1.	No. 2.
Thickness (x y) of bottom plate ..	29/32 in.	1 5/32 ins.
Approx. av. diam. core-legs.....	2⅞ ins.	2⅝ ins.
Area of base of equiv. cylinder....	4.4 sq. ins.	5.0 sq. ins.
Volume of equiv cylinder.....	4 cu. ins.	6.5 cu. ins.
Weight (vol. × 0.26) for 1 core-leg.	1 lb.	1.7 lbs.
Weight (vol. × 0.26) for 3 core-legs.	3 lbs.	5.1 "

The final net weight for each wheel was determined as follows:

No. 1. .....611.95 + 39.78 + 1.2 — 3.0 = 649.93 lbs.
No. 2. .....658.0 + 45.9 + 1.2 — 5.1 = 700.00 lbs.

The calculation for No. 1 was made from the pattern-drawing for a 650-lb. wheel; that for No. 2 from the pattern-drawing for a 700-lb. wheel. The cleaned wheels made from these patterns are averaging 655 and from 700 to 705 lbs., respectively.

Since a variation of 2% above or below the regular weight can be easily caused by variable molding in the making of a car-wheel, it will be seen that the foregoing method of calculation gives reliable results. For castings of soft iron, and of more regular shape than car-wheels, even better results could be obtained.

THE TAYLOR ELECTRIC INTERLOCKING SYSTEM.

In the operation of switches, signals and other appliances in interlocking plants by power (as distinguished from operation by mechanical connections from the tower), three systems are in use: (1) The electro-pneumatic system, in which compressed air is used to operate the various appliances, while the valves and locking are controlled by electricity; (2) the pneumatic system, in which the movements and locking are all operated by air (usually of lower pressure than in the former system); (3) the electric system, in which the movements and locking are effected by motors and other devices located at the several switches, signals, etc., and controlled by electric wires from the tower. The Taylor electric interlocking system, representing the third of the above classes, was invented by Mr. John D. Taylor, of Chillicothe, O., and in 1891 he installed his first plant at East Norwood, O. (near Cincinnati), on the Baltimore & Ohio Southwestern Ry. Improvements were made and new plants put in from time to time, until in 1900 the Taylor Signal Co., of Buffalo, N. Y., was organized to develop the system on a more extensive scale. Since that time a number of plants have been put in, both in this country and abroad. This company does not undertake ordinary block signal work, but confines itself to interlocking plants at junctions, grade crossings, bridges, etc. Mr. W. W. Salmon is President and General Manager, and Mr. John D. Taylor is Engineer; Mr. W. G. Hovey is Superintendent, in charge of the Chicago office.

In the Taylor electric interlocking system, each switch and each signal is operated by its own independent motor, placed on the switch ties for the former and on the post for the latter. The current for the motors is usually furnished by a storage battery plant, charged by a dynamo usually driven by gas or a gasoline engine, but where current is available the battery may be charged direct from the outside supply. In the majority of cases, however, gasoline engines are employed. One important advantage of this system is its flexibility, as the wires may be run to any distance, across bridges, etc.; and the troubles from expansion and contraction which require so much attention in ordinary interlocking plants are unknown. At one interlocking plant, to which we shall refer later, a switch is operated at a distance of no less than 5,300 ft. from the tower. The low cost of the system also makes it applicable to small plants, some plants having as few as six working levers. Many large and complicated junctions and crossings have also been equipped with this system.

GENERATING PLANT.

This plant is usually placed on the first floor of the signal tower, but may be placed in a separate building if desired. The company builds its own electric generators, but supplies any required make of storage battery and gas engine. Storage batteries of 30 to 60 ampere-hours capacity require a 1-K-W. generator and a 2-HP. engine; those of 80 to 120 ampere-hours capacity require 2-K-W. and 4-HP., while a battery of 150 ampere-hours capacity will require a 2½-K-W. generator and 5-HP. engine. As an electromotive force of 110 volts is generally used for the operation of the switches and signals, 55 cells of storage battery are provided. These are of suitable capacity, as determined by an estimate of the number of train and switch movements within the limits of the plant during 24 hours, the aim being to employ cells of sufficient ampere-hour capacity to enable them to run from five to seven days on one charge. The cost of generating current (with a gas engine plant) is estimated at about 20 cts. per charge for the cells of smaller capacity, to 60 cts. for those of the largest size used. The consumption of gasoline is equivalent to about one gallon to 2,850 or 3,000 movements of switches and signals.

The generators are specially designed for the peculiar conditions of service under which they have to work. They have sufficient range in voltage to light 110-volt lamps and also charge the batteries, which sometimes take as high as 150 volts (including the drop in the charging wires). In addition to this, they are required to give a steady voltage, to operate without heating at 150 volts, to be practically sparkless under full-load conditions, and not to spark seriously in case the full load should accidentally be thrown off when the generator is delivering 150 volts. They are shunt-wound machines, and run normally at 1,400 revolutions per minute. The armature is ventilated, and provided with form-wound coils individually insulated. Both the field terminals and both the armature terminals are brought to separate binding posts, so that the generators may be run in either direction by simply changing the outside connections.

The switchboards are made high and narrow in order to fit between the windows in the tower, two boards being used if necessary. The equipment of instruments, switches, etc., on the board depends upon whether or not electric lighting is required, and whether or not a commercial lighting or power circuit is to be provided for lighting or as a reserve. At the top of the board is the voltmeter and below it the ammeter, the latter connected in series with the battery and indicating whether it is discharging or being charged. The ammeter indicates the working condition of the various switches and signals, and should be in full view of the tower man. Between the two instruments are two 16-c. p. lamps, which normally glow faintly. If a ground occurs, one will burn more brightly than the other, indicating whether the ground is on the positive or negative side of the system. Below the ammeter is a switch arranged to throw the voltmeter on either the battery or the generator, and on either side of it are the battery and generator fuses. Below the switch is an underload circuit breaker connected in series with the generator and battery; this opens automatically and prevents current flowing back from the battery through the generator if the engine should accidentally be stopped. Beneath the circuit breaker is the rheostat for controlling the charging current. The signal lamps can be lighted by current from the generator, the switchboard being arranged to enable current to be taken from the storage battery for this purpose in case of a temporary breakdown.

LOCKING MACHINE.

The locking machine in the tower is made in sections, with eight levers to a section. The locking parts consist of tappet bars, dogs, guides, etc., and locking between the various levers is effected by the tappet bars and cross locking in the usual way. The machine is supported upon pedestals or standards and the upper part is cased in, the controllers and levers being enclosed, while the terminal board and locking are exposed. Glass doors in the top of the case permit access to all enclosed parts, and these doors may be locked or sealed to prevent tampering with the mechanism. The case is about 36 ins. wide, and in length it takes about 2 ins. to each lever space. The terminal and fuse board is a slate slab, with three bus-bars running the entire length of the machine. The various incoming wires, together with those from the battery, the various magnets and the circuit controllers, terminate in binding posts or fuse posts on the board. The terminals and fuses for each lever are directly under that lever, and are numbered to correspond with it. The connecting wires from the terminal board to the various controllers are made up in sets, bent to fit, and taped together.

Each lever of the machine has a cam slot, by means of which intermittent motion is transmitted to the corresponding tappet bar. The circuit controllers consist of brushes supported on fixed blocks of insulating material and contact strips carried on similar movable blocks connected to the levers. During the first part of its travel, a lever moves the tappet bar through half its stroke by means of the cam slot; and during this part of the movement no change is made in the electrical connections, as the contact pieces slide along the same brushes. This movement effects the preliminary locking of routes conflicting with that cleared by the new position of the lever. The middle part of the travel of the lever carries the contact pieces from brushes at one end of the controller to brushes at the other end. During this part of the travel the tappet bar remains stationary and the lever is stopped at this point by the latch, which holds it until released by the indication magnet.

After release the lever can complete its travel. During this final movement the electrical connections remain as last formed and the tappet bar is moved the remainder of its stroke, releasing other levers not conflicting with the new position of the lever moved.

The switch movement is controlled by means of two wires in addition to the main common wire and the indication currents which are generated by the switch motor itself are transmitted through the same wires and an indication common circuit. In one position of the lever one of these wires is the control wire and the other the indication wire. In the other position of the lever these conditions are reversed; that is, the wire which was before the control wire is now the indication wire and the indication wire becomes the control wire. Each of these wires is connected to two brushes in the circuit controller, one brush at each end. There are two magnets, termed the indicator and safety magnets. In one position of the lever one of the above wires is connected to the positive end of the battery through the coils of the safety magnet and operating bus-bar, and the other wire is connected to the indication common through the coils of the indication magnet and the indication bus-bar. In the other position the connections are transposed.

The mechanism of the interlocking machine is shown in the cross-section Fig. 1 and the plan Fig. 2. Its construction and operation are as follows:

The lever A slides in its guide B, and is held in place by the caps C and by the adjacent lever guide. In the lever is formed a cam slot D, which gives an up and down movement to the tappet bar E. The dotted circles 1 to 5 in the cam slot (Fig. 2) indicate the position of the tappet bar, which corresponds with like numbered positions of the sliding contact block F. The lever is connected to this block by the rod G, the contact block being thereby forced to move with the lever and to assume the positions 1 to 5. The levers are provided with handles of different colors, as required. A short lever operated by the lever A is used when two switches are to be operated at once. It is always used in connection with a standard lever, to which it is connected by a bar H, shown above lever A in Fig. 1. The short lever has no cam slot, the locking being provided for in the long lever. It is, however, provided with its lever

guide, controller, and set of magnets, the same as a long lever. The lever guide B is fastened to the frame work. The springs, latch, dog, cam, etc., are all mounted on this guide, as shown in Fig. 2, and are held in place by the adjacent guide.

The magnets I and K are fastened to the lower surface of the lever guide, as shown. I is the indicating magnet, and is used on all levers; K is the safety magnet, used only on switch levers. The controller L consists of the brushes M-M, N-N

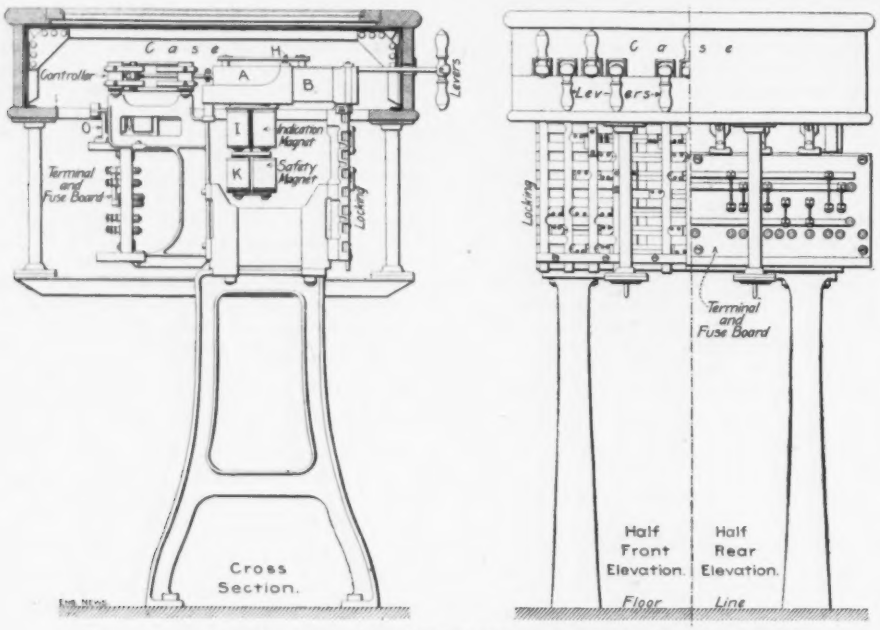


FIG. 1. CROSS-SECTION OF TAYLOR ELECTRIC INTERLOCKING MACHINE.
Taylor Signal Co., Buffalo, N. Y., Makers.

(fastened to fixed blocks of insulating material at either end of the controller) and the sliding contact block F, with its connecting rod G. The indication selector O (Fig. 1) is used only for switch levers. It is operated by the working current, and is so connected that it throws in one direction when the lever is reversed, and in the other when it is put normal. Its function is to close only that indication circuit which corresponds with the position of the track switch and to leave the other open.

The method by which a lever is prevented from completing its stroke, and thereby unlocking conflicting levers, until the switch or signal controlled by the lever has assumed a position corresponding with its new position, will be understood by following out the operations which take place during a complete stroke of the lever. In Fig. 2 a switch lever A is shown in its "full normal" position, and also in its "reverse control and indication" position.

In passing from position 1 to 2, the tappet bar E is raised, thus locking all conflicting levers; the projection P on lever A then coming in contact with projection Q on the latch R, causes the latch to assume the position shown in the lower drawing, thus bringing projection S into the path of the tooth T, as shown in the lower drawing. In moving from position 2 to 3 the tooth T, coming in contact with a similar projection on the cam U, causes it to revolve into the horizontal position (shown dotted in the lower drawing), thus forcing the dog V into the position shown in the same drawing and locking the latch R in its horizontal position.

In moving from 3 to 4, the cam U is revolved into the position shown by full lines in the lower drawing, and the lever is stopped at position 4 by the tooth T coming against projection S. Meanwhile the contact block F, having come into contact with brushes M-M, completes the battery circuit to the motor; this causes the switch to be thrown and locked in position, and the indication current to be sent back through magnet I, lifting the armature W and causing the plunger X to strike the dog V and throw it out from under the latch R. The latch, being thus released, drops to its position, shown in the upper drawing, and permits the lever to move from position 4 to 5, thus completing the stroke, and by lifting tappet bar E, unlocking the levers which do not conflict with the new position of the lever A.

The stroke from reverse to normal acts in the same way. Signal levers also operate in the same manner, with the exception that on the reverse stroke, when the contact block F is in position 4, current is sent through magnets I from the battery, giving an artificial indication and allowing the lever to pass to position 5. The arrangements of the interlocking include the following features:

(1) Due to the locking, the lever A could not have been moved at all had any conflicting routes been set up.

(2) Being free to move, the mechanical construction employed forces the lever to stop at position 4 and prevents it from passing to position 5 (and thus unlocking conflicting levers) until an indication is received which, in the Taylor system, is a proof that the switch has been moved to, and locked in, a position corresponding with that of the lever.

(3) A lever once moved to or beyond position 3 can neither move forward beyond position 4 nor back beyond position 2 without an indication or release locking movement, and this cannot be given unless the function is locked in a position corresponding with that of the lever.

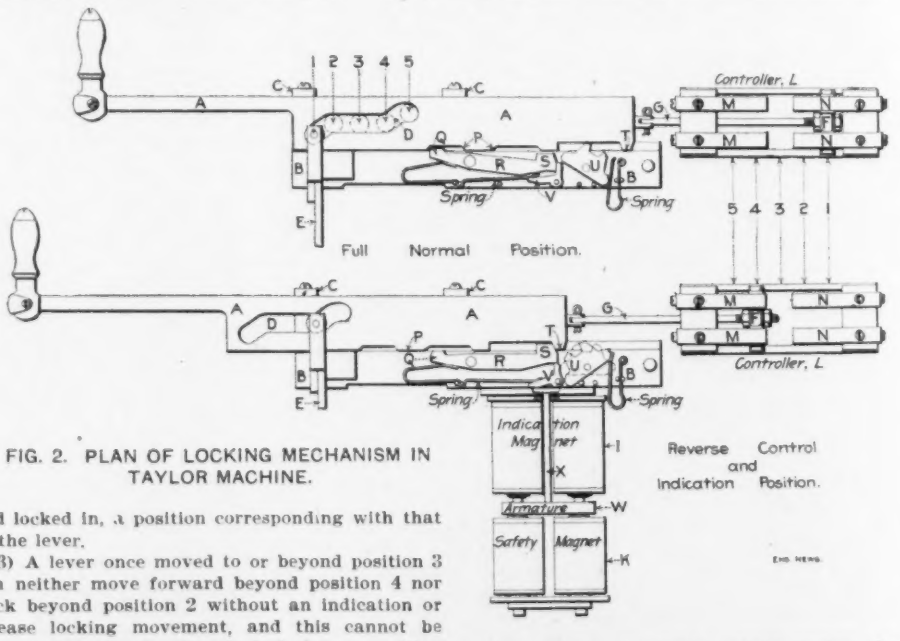


FIG. 2. PLAN OF LOCKING MECHANISM IN TAYLOR MACHINE.

SWITCH OPERATING MACHINE.

As already described, each switch is operated by its own electric motor. These motors are specially designed for this service, and are manufactured by the company. The switch movement is controlled by a pole changer which is located at the switch, and which is shifted automatically by the lock bolt in the last part of its movement, after it has passed entirely through the lock rod.

A plan of a complete switch equipment is shown in Fig. 3. Here A is the motor and B the shaft flexible in all directions, so that the care and maintenance of alinement between the motor and the gear frame is unnecessary. The train of gearing reduces the speed of the motor and increases the power to an amount suitable for moving the switch and detector bar. After the machine has entirely completed a stroke, the gearing disengages the motor by means of a clutch arrangement, the motor being then free to continue revolving. It thus generates a counter current to operate the release locking, which frees the lever in the tower. At C is the pole changer. The movement of the switch, detector bar and lock plunger is effected by the pin D on the main gear, which is connected with the lock movement by the rod E, and with the switch by the crank cam F. The lock plunger, detector bar and pole changer are operated through the lock movement G. Motion is transmitted to the T-crank H by rod E, to the lock plunger by link J, and to the detector bar by link K. As both the plunger and detector bar are driven by the same crank, if a train prevents the movement of the bar, the plunger cannot be withdrawn or the switch thrown. Should an attempt be made to open a switch while a train is passing over it, a fuse would be blown out on the interlocking machine, thus opening the circuit. Motion is imparted to the pole changer C through the movement L, after the lock plunger has passed through the hole in the lock rod M. The movement of the pole changer accomplishes three things: (1) It cuts off the working current from the motor; (2) it reverses the armature connections, and (3) it completes the indicating or release-locking circuit. It may be operated by the rod N or by means of magnets, a revolving circuit breaker cutting the current off from the magnets whenever the switch is in its full normal or reverse position.

The operation of the switch machine is as follows: When the motor is set in motion by the current it operates the train of gearing and carries the main gear wheel, with pin D, through a complete revolution. During the first third of the revolution the lock bolt is withdrawn and the detector bar N simultaneously raised by means of the lever O and rod P. The pin D then comes in contact with the outer end of the crank cam F, causing the switch to be thrown during the next third of the revolution, while during the remainder of the revolution the lock bolt is returned to its place and the detector bar lowered. As the lock plunger passes through the lock rod the pole changer is thrown and at the same time the motor is disengaged from the gearing, as already explained. The mechanism is enclosed in a hinged sheet-iron casing, secured to the frame by a padlock. The gear frame, lock movement and stock rails are bolted to a tie-plate, which maintains the parts in proper relations. The lock, front and

throw rods are shown at M, Q and R, and both lock and throw rods are bolted by the lock plunger.

SIGNAL OPERATING MACHINE.

Each signal post has a single electric motor, only one motor being used, whether the post carries one or more arms; but if there is more than one arm a selector is used to connect the motor with whichever arm is to be operated. Each arm is connected to its own circuit breaker, also attached to the post. The machine consists of the motor, a train of gearing and a grooved pulley for

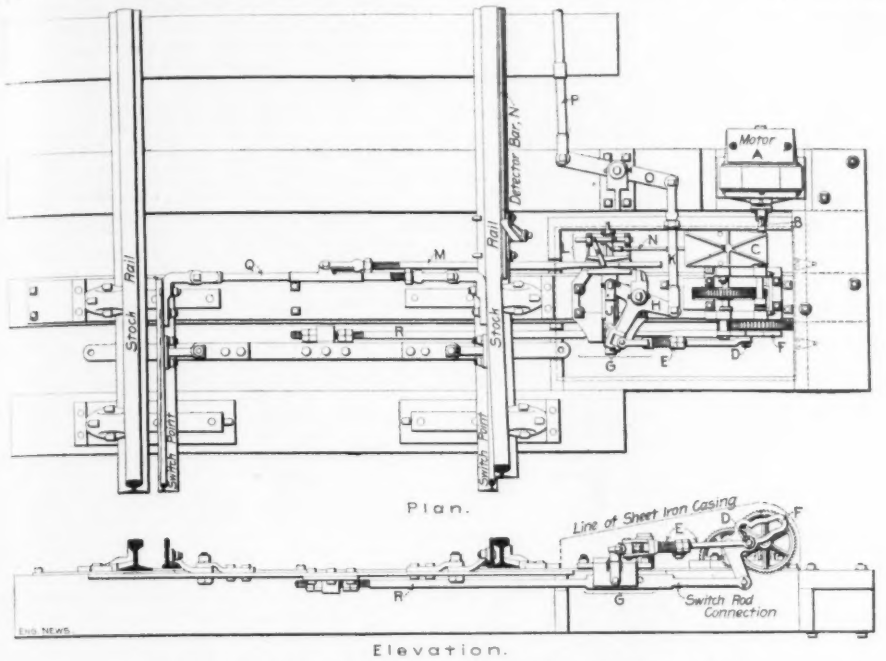


FIG. 3. PLAN OF TAYLOR SWITCH OPERATING MECHANISM.

a chain, the whole being enclosed in a sheet-iron casing A, as shown in Fig. 4. The chain B is carried down to the counterweighted lever C, to which is connected the vertical rod D operating the semaphore arm. In a two-arm signal each arm has its own counterweight lever and chain. If the motor is revolved in one direction it raises one lever (lowering that arm), and if revolved in the opposite direction it raises the other lever (lowering the other arm). The direction of revolution is determined by the position of the contacts in the switch box located at the switch, and this position is controlled by the position of the switch. With three or more arms, the chain is connected to a single counterweighted lever, and operates any one of the signal-rod counterweighted levers through the medium of a hook selector H. A flexible connection E between the chain and counterweight lever prevents injury to the mechanism in case the arm should come against its top before the brake has been set by the circuit breaker.

Another rod F, attached to the arm casting, operates the circuit breaker G. The upper arm on the two-arm post has a circuit breaker with two pairs of contacts, one pair controlling the motor circuit of this arm, and the other controlling the circuit of the distant signal when the home signal is at "clear." The other arm has a circuit breaker with only one pair of contacts, as there is no distant signal to be controlled by it.

The signal controller connected to the signal lever in the interlocking machine has one normal and one reverse pair of stationary contacts, and one sliding contact piece connected with and moved by the lever. One of the reverse points is connected with the positive end of the battery and one of the normal points is connected with the indication (or release locking) wire. The other two points are connected with one terminal of the indication magnet, the other terminal being connected to the signal control wire. Only one wire is required for either a single or double arm signal for both control and indication. Where there are two or more arms on one post, there may be a separate lever on the interlocking machine for each arm, or they may all be worked from the same lever by means of a switch box or ground selector.

When current is transmitted to the motor by reversing a lever in the tower, the armature is set in motion, driving the train of gears and winding up the chain, so that the counterweight lever pushes the rod up and so lowers the arm. When the arm has reached its "clear" position, the circuit breaker shuts off current from the motor and applies a break to the gearing. In cases where it is desired to break the circuit to a switch, another form of circuit breaker is used, which opens the switch circuit as soon as the arm starts to clear. To return the signal arm to the "stop" position, the lever in the tower is put in its normal position, cutting off the current from the brake magnets and motor. At the same time a circuit through the motor and indication magnets is set up, but this is open at the signal circuit breaker. The motor being free, the counterweight lever falls, raising the signal arm and unwinding the chain, which causes the motor to revolve backwards. As the arm reaches the "stop" position, the circuit breaker completes the indication circuit and the motor (now acting as a generator) sends in the indication and releases the lever in the tower.

The signals may of course be placed on poles of wood or iron, on bracket poles, or on signal bridges, as may be desired. Dwarf signals are not provided with motors, but have a double solenoid and two circuit breakers enclosed in the base of the casting which forms the post. When the working or low-resistance coil of the solenoid is energized, it exerts a magnetic pull of sufficient power to move the arm to the "clear" position, in which it is held by the retaining or high-resistance coil. At the same time it compresses a spring encircling the operating rod, which thus assists in returning the arm to the "stop" position when the current is cut off. One circuit breaker controls the indication or release locking circuit, and is closed only when the signal is in its normal position; the other controls the working circuit and is open only when the signal is reversed.

RELEASE LOCKING.

The release locking is effected by an electromagnetic device placed under each lever of the interlocking machine, and actuated by a dynamic current furnished by the motor (at switch or signal) controlled by this lever. The current is generated by the motor continuing to revolve by its own momentum after the working current has been cut off, as already explained. The electromagnetic device is thus actuated, however, only when a switch has moved to a position corresponding with that of the lever and is bolt locked in that position, or when a signal arm has moved to its "danger" position. Crosses between a release-locking (or "indication") wire and a common return wire (or ground), or any other wire of the system, can do no more than prevent the release locking (or, as it is called, the giving of an indication); they cannot cause the giving of a false "clear" indication. Owing to the use of electric connections, the indications are given instantaneously upon the completion of the locking of the switch or of the stopping of a signal in its "stop" position, whatever may be the distance between the switch or signal and the tower. If a switch fails to make a complete movement, as in the case of an obstruction between the switch and the stock rails, the towerman can return the switch to its former position and then make another effort to perform the desired movement. In many cases the second attempt will prove successful, thus avoiding the necessity of sending a man to attend to the switch.

The following conditions must be fulfilled before the indication current can flow through the magnetic device of the release locking: (1) The driving or working current must be cut off; (2) the indication wire must be put into connection with the armature, and (3) the connections between the armature and fields must be reversed. The first condition might be accidentally fulfilled by a broken wire and the second by crossed wires, but the third would require two particular breaks and crosses in certain relation to one another.

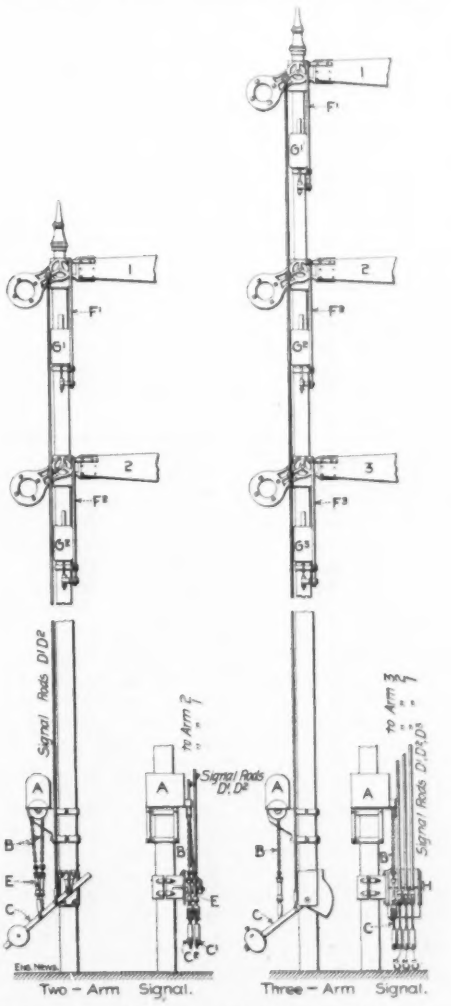


Fig. 4. Signal Posts, with Motors and Circuit Breakers.

The accidental fulfilment of the three conditions is almost beyond the range of possibility.

In many cases, where conditions are favorable, the double benefits secured by the use of detector bars and electric locking may be obtained by means of a track circuit instead of the detector bars, at little or no increase in cost. As the style of relay ordinarily used in track circuit work is not adapted for use in the Taylor system, a special relay is used. This is designed to meet the requirements, which demand a form of contact

that will carry a heavy current without disintegration while current is flowing through the contact points. This relay acts as a magnetic blow-out, and instantly destroys any arc formed in this way.

ELECTRIC INTERLOCKING OF A GRADE CROSSING AT MARION, O.

As an example of the Taylor interlocking system, we give in Fig. 5 a plan of the grade crossing at Marion, O., which has recently been equipped with this system. At this point there is the western end of a 22-mile section of double track line used jointly by the Erie R. R. and the Cleveland, Cincinnati, Chicago & St. Louis Ry. (Eng. News, April 11, 1901). Beyond it are two parallel single tracks for the two roads, that of the Erie Ry. being for the Chicago Division, while the single track of the Cincinnati Division branches off here. The three parallel east and west tracks are crossed by the single track line of the Columbus, Sandusky & Hocking Valley Ry. (east of the union station), and the double track line of the Hocking Valley Ry. (west of the station). Both these lines are connected with the east and west lines by spur track and the former also has its own station.

The interlocking plant therefore includes both junctions and crossings, with two double crossovers. The machine has 58 levers and 84 spaces, as follows: 27 levers in 41 spaces for 41 switches, 29 levers in 29 spaces for 41 signals, 2 lock levers and spaces, and 12 spaces for spare levers. The entire plant is controlled from one tower, and the signals are mostly placed upon posts, but there is one signal bridge at the station. The generating plant includes a 4-HP. gas engine made by the Fairbanks & Morse Co., a 2-K-W. Taylor generator and a storage battery of 100 ampere-hours capacity.

In designing this plant it was required that trains on the north and south lines should be able to stand at their respective stations (both south of the crossing) without blocking traffic on the east and west lines. This required a special arrangement, as the State law of Ohio requires a derail 300 ft. from the crossing, and under ordinary conditions the closing of this derail to admit a train to reach the station would block all signals against trains on the other lines. To provide for the above requirements, an auxiliary wire circuit is run from these derails to a relay and battery in the tower, and a second derail is put in each line between the station and the crossing, about 50 ft. from the crossing. When a train on either line approaches from the south, and a clear route has been given for any of the east and west lines, this train is stopped by the signal and outlying derail in the usual way. If the train is to come up to the station, however, the towerman can, by the special wire circuit, release the locking, when he can lower the signal and close the outlying derail. The second derail, however, remains open, and as the train has been brought to a stop at the first one, if it should overrun the station, it would be going at so slow a speed that it could not reach the crossing when derailed.

ELECTRICALLY INTERLOCKED JUNCTION; ILLINOIS CENTRAL R. R.

The Taylor interlocking system has recently been installed at the Bridge Junction at Cairo, Ill., on the Illinois Central R. R., where the double track runs into a single track over the Mississippi River bridge. This plant has two special features: (1) The operation of a switch at the very exceptional distance of 5,300 ft. from the tower, and (2) the use of electric lamps of 1 c. p. for the signals, these lamps being operated from the battery. The distance from the tower to the movements governed is a matter of very little moment in the Taylor system, as the connection is simply a matter of laying electric wires. In other systems, however, the operation of long lines of rod connections or air pipes is limited by difficulties in properly transmitting the power. The Bridge Junction plant has 23 working levers, operating 14 signals and 16 switches. This plant has a 6-HP. gasoline engine, built by H. D. Witts; a 2-K-W. Taylor generator, and a storage battery of 150 ampere-hours capacity. The wires are carried overhead across the bridge, and there is a track circuit so that signals cannot be lowered until the bridge is closed and locked.

The Taylor system has been applied to a number of drawbridge plants, one of the latest being at Galena, Ill., on the Chicago, Burlington & Quincy Ry. Here a four-track line runs into a single track crossing the bridge, and this opens out to a double track on the opposite side. The wires are carried overhead, but in some cases a cable is laid on the bed of the stream.

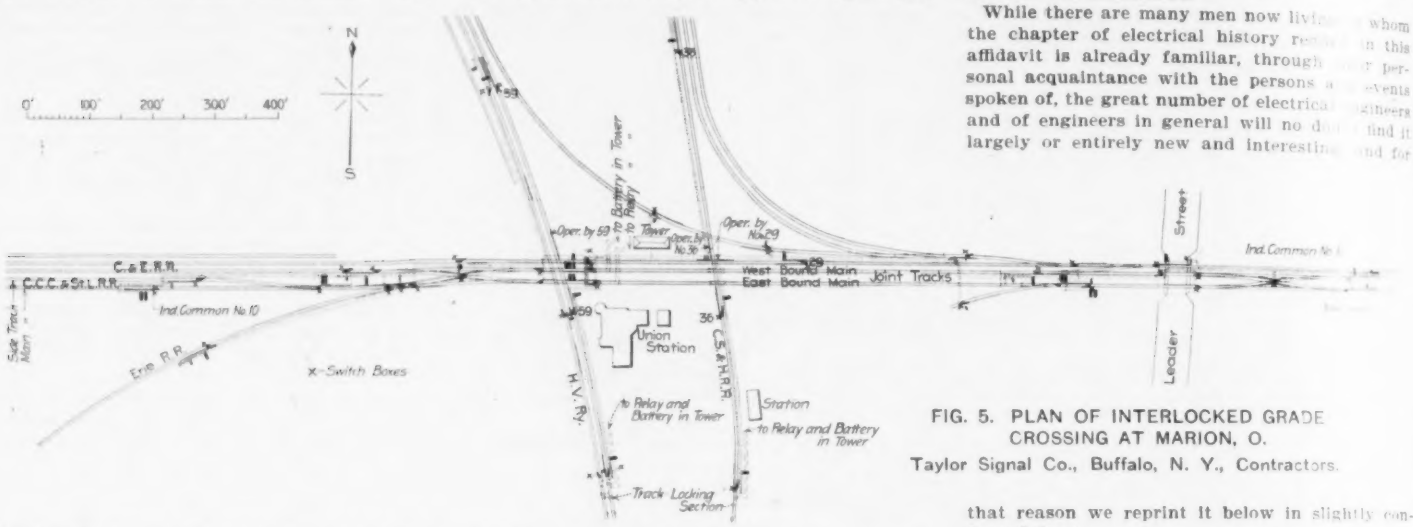


FIG. 5. PLAN OF INTERLOCKED GRADE CROSSING AT MARION, O.
Taylor Signal Co., Buffalo, N. Y., Contractors.

AN INTERESTING FRAGMENT OF ELECTRICAL HISTORY.

The development of electrical engineering, and equally so the rise of electrical science, is entirely a matter of the last few decades. So recent is this development, in fact, that it has not yet been possible to draw up a history of the art, or to gather all the materials required for such a history. On this account unusual interest attaches to any historical narrative bearing on this subject, especially so when this narrative comes from an engineer who is not only intimately acquainted with the principal personages in his story, but has been and is himself actively concerned in the development of electrical engineering.

Such a narrative is contained in a document which has come into our hands. It is in the form of an affidavit by Mr. William Stanley, the founder of the Stanley Electric Mfg. Co., of Pittsfield, Mass., submitted as testimony in a suit instituted by the Westinghouse Electric & Mfg. Co. against the Stanley Electric Mfg. Co. The affidavit concerns itself specifically with the development of the induction motor, but in that connection it details many facts about the early history of general alternating-current working in this country. It speaks, for instance, of the origination of the commercial transformer, together with its first fully successful utilization in the lighting system of Great Barrington, Mass., and of the introduction of the inductor type of alternating-current generator. Almost equally interesting is the reference to the formation of two electric manufacturing companies which stand to-day among the largest in the world. This part of the story is worth special notice because it clearly brings out how closely the commercial side of electrical development has followed the scientific advance in electricity, and how the latter worked ahead of the former, producing results of practice before the nature of the involved phenomena was understood.

While there are many men now living to whom the chapter of electrical history recorded in this affidavit is already familiar, through their personal acquaintance with the persons and events spoken of, the great number of electrical engineers and of engineers in general will no doubt find it largely or entirely new and interesting, and for that reason we reprint it below in slightly condensed form:

In 1879 I (Mr. William Stanley.—Ed.) was engaged in the nickel-plating business in New York city, at which time I became acquainted with Mr. Hiram Maxim, whose personality and work so impressed me that I disposed of my nickel-plating business and engaged myself to him as an assistant. In those days Mr. Maxim was one of the foremost inventors in electrical engineering work, being the founder of the United States Electric Light Co., whose factories were located on Sixth Ave. and 24th St., New York city. After serving a short apprenticeship with Mr. Maxim I was promoted to the position of his first assistant, and in that capacity had general charge of the development of such new work as his company undertook. When Mr. Maxim left the United States for the Paris Exposition in 1881,* I resigned from the United States Co., and for a short time was engaged assistant to Mr. Edward Weston, of the Weston Electric Light Co., of Newark, N. J.,† at which place I became familiar with the apparatus and machinery then largely used for the lighting of public buildings, hotels, etc., as well as the well-known Weston arc lighting system. In 1882 I was engaged by the Swan Electric Co. to carry on some experiments for them at Boston, and remained in their employ for about one year, during which time I invented and perfected the methods of exhaustion for incandescent lamps now largely used throughout the world. During the years 1883 and 1884 I conducted a private laboratory at Englewood, N. J., devoting myself to experimental work on storage batteries, the perfection of methods for the manufacture of incandescent lamps and other electrical engineering problems. At this time I determined that I would devote myself to experimental work and the working out of engineering problems, to which purpose I have since adhered.

ORIGIN OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

In 1884 I became acquainted with Mr. George Westinghouse, who at that time was President of the Westinghouse Air-Brake Co., and the Union Switch & Signal Co. and other enterprises, and who was desirous of getting into the field of electric lighting. After several interviews with Mr. Westinghouse I made a contract with him to the effect that I should devote my time to the development of certain lines of investigation which I was interested in, which, in case they were brought to a successful issue, Mr. Westinghouse agreed to promote as a business enterprise and give me an interest as a reward for my labors. During this year I installed and equipped a lamp factory for the manufacture of incandescent lamps at Swissvale, Pa., at the works of the Union Switch & Signal Co., designed some continuous-current machines adapted to operate incandescent lamps in isolated plants and was generally occupied with the development of a system for this line of work.

It is to be remembered that during these years, namely, from 1881 to 1884, the great problem presenting itself to

*Mr. Maxim afterwards settled in England and devoted himself to inventions in the field of military appliances, of which the Maxim gun is perhaps the best known. His firm was merged in the present company of Vickers Son & Maxim.—Ed.

†Mr. Weston later withdrew from the electric lighting business and took up the manufacture of electrical measuring instruments. He is now the head of the Weston Electrical Instrument Co., of Newark, N. J.—Ed.

electrical engineers was to devise some method by which electricity could be publicly served over a more extensive area than was then possible by the systems in use. The necessities of this problem were thoroughly understood. Many calculations had been made and published showing the enormous expenditure required to lay down the mains sufficient to generally distribute electricity in cities upon the systems then known, and it was generally understood that the development of the art must hesitate and remain dormant until some system could be devised by which larger areas could be served, with a much less cost for mains and plant than was known at that time.

Many suggestions were offered as solutions for this problem, both in the United States and in foreign countries. Among these were the multiple series and series multiple systems of Brush, Weston and others, and the series transformer system of Gaulard, operated by alternating currents. To the solution of this problem I devoted my entire strength, feeling that it was worthy of the best efforts that I could give, and inspired by the hope that I might at least take some part in the solution.

THE ORIGIN OF THE COMMERCIAL TRANSFORMER.

In 1883 and 1884, I worked at an attempt to devise a general system of distribution employing alternating currents, but found that I was not sufficiently well posted on this branch of engineering to proceed further with it. In 1885, while at Pittsburg, I began to have definite notions as to the methods of operation of induction coils energized by alternating currents, and conceived of the controlling actions and governing properties of the counter electromotive force of induction coils.

In the spring of that year I was taken ill and removed to Great Barrington, Mass., for my health. While there and while recovering from my sickness I carefully studied this question and became convinced that a general system of distribution employing alternating currents at constant potential and induction coils designed for the purpose and connected in parallel connection would offer a comprehensive solution of the problem.

I submitted the plans which I had thought out to a number of my friends, both for the purpose of talking the matter over with them and because I felt growing confidence in the value of my ideas, and as I was at this time retained by Mr. George Westinghouse in a consulting capacity for the Westinghouse company's interests, I endeavored to interest him in the development of this subject, but found that he was averse to the expenditure of money on experimental work for the furtherance of my plans.

As I became infatuated with the subject and thoroughly believed that I had found a true solution of the problem of successfully distributing electricity, I finally made up my mind to employ my own money for the construction of a plant which would demonstrate beyond peradventure the value of my work. As this work conflicted in a measure with the existing agreement that I had with Mr. Westinghouse it became necessary and advisable to rearrange the contract arrangements between us and a new agreement was drawn up in which I agreed to sell to Mr. Westinghouse $25,000 worth of the stock for $12,500, devoting the money thus obtained to the development of my plans. It was necessary for me to do this as Mr. Westinghouse refused to let me proceed with the work, unless I paid for it, and suggested this method as the means for furnishing the money required.

Having gotten out of the way in this manner the obstacles which prevented the further development of the work, I proceeded to hire an old disused rubber mill at Great Barrington, and to engage several assistants, that I might construct the apparatus necessary to demonstrate the system. This work required several months of continuous application, and resulted in the building of a plant widely known as the Great Barrington plant, by which alternating currents at 500 volts pressure were generated and led to the town of Great Barrington, where transformers were connected in multiple circuit. The circuits were installed for the purpose of lighting part of the business portion of that town. The successful operation of this plant and the undeniable proof that the means had been found by which electricity could be served through very small conductors over and throughout a large area greatly interested Mr. Westinghouse, who visited the plant in May of 1886 in company with Mr. Guido Pantaleoni, Manager of the Westinghouse company; Mr. C. H. Jackson, Mr. Harry Byllesby, Mr. Walter Kerr, of Westinghouse, Church, Kerr & Co. and Mr. Frank Pope, in the Westinghouse interest, and other gentlemen.

As soon as these gentlemen appreciated the practical operation of the plan and saw that it would offer a general solution of the distribution problem, they immediately took steps to discontinue the development of all other departments of electrical work at Pittsburg, devoting themselves to the development of the manufacturing details required for the production of my line of apparatus.

From the spring of 1886 until 1888 the Westinghouse company increased its capital and manufacturing appliances for the purpose of devoting and introducing my work in the lines that I have mentioned. The perfection of the details of the system, the construction of standard sizes of apparatus and the general development of the system as a whole occupied a large portion of my time, from 1886 to 1888. The work was also largely developed by a skilled corps of men, headed by the late Mr. Oliver Shallenberger,* who, both by their contributory and original work, greatly helped in the perfection of the system. But no apparatus was devised or originally entered into the system or has since been added to it (excepting the application of various types of alternating-current motors) other than that shown at Great Barrington; for, as the system left my hands at Great Barrington, considered as a system of distribution, it was complete and has not since been substantially modified, although a number of devices have been designed for the utilization of alternating-currents when so distributed.

THE INDUCTION MOTOR INTRODUCED IN AMERICA, AND FAILS.

In 1888 Mr. Nikola Tesla brought before the American Institute of Electrical Engineers a proposal to operate alternating-current motors by employing the principle of the rotating-magnetic field. This principle, discovered by Deprez in 1883, and applied to induction motors by Galileo Ferraris in 1885 in Turin, was patented by Mr. Tesla in 1888, and publicly announced in 1888 and acquired by the Westinghouse company shortly afterwards. At this time I was general consulting engineer of the Westinghouse company and in such capacity was of course familiar with the development of the company's business, the various lines of work that were experimented upon and was in frequent consultation with the chief electrician and members of his staff at Pittsburg on the problems that were being presented from time to time.

Mr. Tesla was engaged by the Westinghouse company for the purpose of putting his invention into practical use. To this end he was supplied with assistants possessed of the knowledge of alternating-current engineering that the Westinghouse company had then obtained. The so-called Tesla system of the transmission of power consisted of a multiphase generator, of four conductors connecting two-phase circuits of the generator with the two circuits of the motor, together with the usual appliances in general use for governing and transforming the currents employed. The first attempt made by the Westinghouse company to construct an operative Tesla motor employed the following apparatus. One of my alternating-current machines, wound with two coils in a well-known manner, was put at Mr. Tesla's service. Motors having inwardly projecting poles similar in construction to the field magnets of my generators formed the stationary part of the motor, the armature of which was wound like an alternating-current armature, but with closed circuited coils.

After this apparatus had been gotten together and gotten ready for test, it was found that it was quite inoperative and for the following reasons: First, that when the motor was connected to the generator the reactive effects of the motor were of such magnitude as to demagnetize the generator, reducing its E. M. F. and consequently its output to a very great extent. In fact, it was found impossible to run two small motors from a single 50-HP. generator, as the combined action of these motors demagnetized the generator, preventing it from generating electricity. These small motors were of about 5-HP. capacity each.

Considering that these results were due to lack of skill in design or to some undiscovered property of the motor, attempts were at once made to remedy the defects. A department or division of the company's workshops was set aside for the purpose of affording every facility for the study and development of the work. Generators and motors differing from each other in details of construction were devised and constructed at enormous cost for the purpose of producing a machine which could be used commercially. In my frequent visits to the factory at Pittsburg, I, of course, was familiar with the work that was going on and continually heard reports as to the progress or want of progress in the attempts to develop Mr. Tesla's inventions, and I well remember that I was called in consultation by the officers of the company on various occasions and was asked whether or not I believed that anything could be worked out of the Tesla motor that would merit commercial adoption. This work proceeded week after week, month after month, until the Tesla motor problem became a threadbare topic and the question was seriously debated many times as to whether or not it would pay the company to proceed further in the development of this work, in view of the constant failure to obtain commercial results.

So serious were these difficulties that the proposals to deliver apparatus for transmitting power by the Tesla motors, which were given to the agents of the company, and by them to the public, were postponed from time to time until finally general notice was sent to the agents of the company that they could no longer tell when orders could be filled by the Tesla apparatus. I remember distinctly that it was with great regret that the company was obliged to come to this conclusion and that it formed the subject of many discussions between the engineering department of the company and its executive officers. Mr Henry M. Byllesby, who was General Manager and Vice-President of the Westinghouse company, frequently talked the matter over with me and expressed himself in no uncertain terms as to the lack of value of the purchase of the Tesla inventions for power transmission purposes and the failure on the part of Mr. Tesla and his assistants to make them commercially useful.

*Inventor of the Shallenberger meter.

In 1890, I severed my relations with the Westinghouse company for personal reasons. At this time there were, so far as I know, no Tesla motors in commercial operation, although continuous endeavors were made to perfect the motors from the time of the purchase of the patents, and large sums of money were expended in these attempts. I remember, that, in a conversation with Mr. Byllesby, he stated to me that they had spent $300,000 in experimental work in the endeavor to make the Tesla motor practicable, and he further offered, on behalf of the Westinghouse company, to give me $100,000 in cash if I would design a Tesla motor, or any other type of motor, which could successfully operate, in view of the fact that they had taken a great many orders for the delivery of motors which they were unable to fill.

The only alternating-current motors that were made by the Westinghouse Electric Co. that were in commercial operation in 1889 or 1890, as far as I am aware, were a few synchronous motors or, in other words, alternating-current machines used as motors. The difficulties found in starting these motors and getting them in step and handling them have always formed objections to their general use, and confined their application to those cases in which ready means were at hand for getting them up to their synchronous speed.

ORGANIZATION OF STANLEY ELECTRIC MFG. CO.

In the winter of 1890 and 1891 I organized a company at Pittsfield, Mass., for the purpose of making certain electric appliances. The first work that we attempted was the production of a new type of transformer, and we largely devoted our attention to this work until 1892. As at this time there were no alternating-current motors obtainable on the general market, and as there was a great demand for such motors from the electric lighting stations of the country, whose number was rapidly increasing, with my associates, Messrs. Kelley and Chesney, I took up this question and attempted to design a motor which would meet the demands of the trade, viz., to produce a self-starting motor that would meet the general requirements for the distribution of small power, and give to the alternating-current system the same advantages that were possessed by the continuous-current system when operating continuous-current motors.

A SELF-STARTING ALTERNATING-CURRENT MOTOR DEVELOPED.

In our investigations in connection with this work we found it necessary to introduce into the art a new piece of apparatus which had not before been manufactured and used in connection with electric lighting systems. I refer to the commercial condenser—as we found that we could design a novel type of motor to which was permanently connected a condenser, and by such combination obtain a motor in which the current supply was proportioned to the work furnished, a result that before this time had not been successfully accomplished. In fact, in developing this work we did not adopt or make use of the principles of the rotary field employed by Ferraris and Tesla in their work on motors, but taking the alternating-current transformer as a general model upon the theory of which to design a motor, we constructed a motor in which the stationary part was represented by the primary coils of two transformers, the secondary coils of which when properly connected together, were rotatable and formed the armature. This motor we introduced to the public as a transformer motor. It was so accepted both here and abroad, and publications and descriptions of it distinctly pointed out that it did not operate upon the so-called rotating field principle, but relied upon the well-known transformer effects produced in a peculiarly organized structure.

The first successful transformer motors devised by my associates and myself at Pittsfield were completed about the early summer of 1892, and as the development and manufacture of these motors required more capital than the Stanley Electric Mfg. Co. had at its disposal and required for its other business, the capital of the Stanley company was increased several times in order to provide the necessary funds for developing and carrying on the business in a commercial way.

The operation of these motors required that the generators should furnish them with at least two alternate-currents differing in phase. As the Stanley company did not at this time make multiphase generators and as the introduction of the motors was limited by the lack of the necessary generators, an arrangement was undertaken between the General Electric Co. and the Stanley company under which it was agreed that the General Electric Co. would construct and furnish generators for the express purpose of running the motors above mentioned. A number of such generators were made by the General Electric Co. for operating our motors, which were the first self-starting alternating-current motors practically introduced in this country, while the first generators built—subject to our approval—were built by the General Electric Co. and were the first multiphase generators built for the express purpose of distributing power by means of multiphase alternating currents.

During this time various proposals were made to my associates and myself by the owners of the Tesla patents with a view of their sharing with us the alternating-current motor field. The President of the Westinghouse company submitted one proposition which contemplated turning over to the Stanley company all of their rights for

the manufacture of alternating-current motors under the Tesla and other patents and receiving therefore a portion of the capital stock of our company, it being understood that we should apply to the Tesla motor the knowledge which we had acquired and applied in the development of our own transformer motor. These propositions were submitted in due course of business to the management of our company, and were seriously considered by them. But as it seemed to those in control of the business management of the Stanley company that the proposed alliance would add nothing of strength to their present position,no agreement for a joint interest in the motor business was completed

ORIGIN OF THE S.K.C. INDUCTOR ALTERNATOR.

As those financially interested in the Stanley Electric Mfg. Co. saw the successful operation of the early motors of which I have spoken, they became desirous of extending the field of operations of the company, and manufacturing not only the motors, but the generators necessary for supplying them with current, the temporary arrangement with the General Electric Co. was, therefore, cancelled, and the Stanley Electric Mfg. Co. proceeded to enlarge its capital and add to its equipment the necessary appliances for the manufacture of alternating-current multiphase generators wherewith to operate self-starting transformer motors, which were used in sizes up to and not exceeding 50 HP. at that time and which were further used as synchronous motors in those cases where large powers were required. These alternating-current multiphase generators which were designed by the engineers of the Stanley company, differed from all alternating-current multiphase machines ever before designed, and became known by a separate and distinct type-name to distinguish them from the machines of the prior art. The multiphase alternators of the Stanley company were known in the art as Inductor Machines, the term "inductor" being devised to distinguish this type of generator from all others.

EUROPEAN WORK IN THIS FIELD.

I have attempted to outline the development of the transmission of power by means of a peculiar apparatus bearing my name, I mean the apparatus made by the Stanley Electric Mfg. Co. and especially its multiphase generators used both as motors and generators, and its induction transformer motors. But lest I should appear to claim that the entire art was developed by means of the labors of the engineers of the Stanley Electric Mfg. Co., I deem it proper to say that at the same time the art was also greatly aided and developed by the work of Herr Dolivo Dobrowolski, of Berlin, Germany, a distinguished physicist and engineer, who, taking the fundamental theory and proposition of Professor Ferraris, namely, the discovery of the application of the rotary field to induction motors, produced the first successful rotary field motor system. It is generally conceded that the design, construction and introduction of the rotary field motor was peculiarly the work of Dr. Dobrowolski, for Dobrowolski plainly showed how it was possible to design an induction motor operating upon the rotating field principle that could be commercially operated from a multiphase generator; and, speaking in detail, how such motors could be constructed to first take a current from the multiphase source in proportion to the work developed by the motor; second, how they could be constructed to start with sufficient torque from a state of rest without reacting on the generating source; and, thirdly, how a general system of distribution could be devised in which a large number of motors might be installed without interference with one another. It was necessary that a solution of these problems should be found before the rotary field motor could be put into commercial service.

I may state, as illustrating this statement, that Dobrowolski and Brown erected the famous Lauffen-Frankfort transmission plant, over 100 miles in length, by which the water power at Lauffen was converted into multiphase currents and conveyed in the form of electrical energy to Frankfort, where it was re-converted into mechanical power by means of rotary-field motors. This plant was installed and operated without employing any of the knowledge, plans or engineering data of the Westinghouse Electric & Mfg. Co.'s engineers. In fact, while the Westinghouse company was unsuccessfully endeavoring to find a means of operating a few small rotary field Tesla motors over inconsiderable distances, Dobrowolski and Brown were constructing and operating the tremendous installation above referred to; and I may plainly state that the Westinghouse company were unable to make an operative induction motor until after the publication of the electrical data employed by Dobrowolski and Brown in the Lauffen plant had become public property.

AN ADJUSTABLE MOLD FOR MAKING CONCRETE BUILDING BLOCKS.

The accompanying cut illustrates a mold for making building blocks of concrete or cement mortar which has recently been put upon the market by Mr. N. F. Palmer, of 150 Snedeker Ave., Brooklyn, N. Y. This mold may be employed to form solid or cored blocks of a large number of sizes, forms and face designs by means of simple adjustments in the operating mechanism and parts of the mold. The machine illustrated, for example, with its attachments, molds 36 different full-size blocks and 288 different fractional blocks. The dimensions of the full-size blocks vary from 6 to 16 ins. in width, and from 26 to 36 ins. in length, the depth being uniform for all blocks and 9 ins. The width of cores used varies from 2 ins. to 5 ins., and the number of core holes may be raised from one to several.

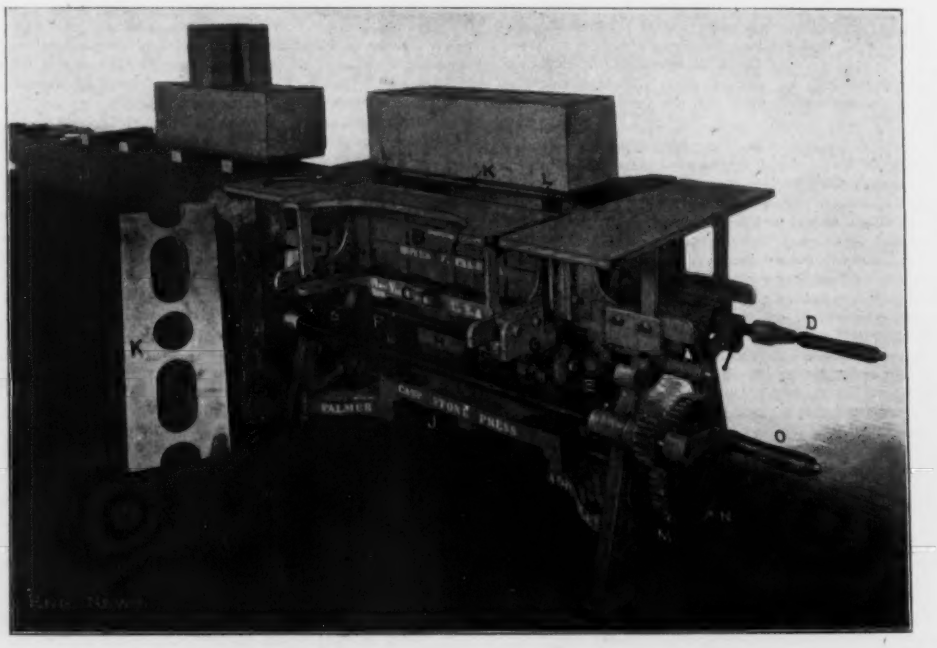
The machine consists of a table-like frame composed of two pairs of legs connected by a stretcher and surmounted by a top which forms the bed plate of the mold proper. The mold consists of two side plates and two end plates arranged to slide on the bed plate. The axes of travel of the two pairs of plates are at right angles to each other and the plates are maintained accurately in this rectangular relation by stout guides on the bed plate. By means of this construction all four sides of the mold can be opened simultaneously. Movement is actuated by means of spur wheels gearing into racks. The cores are carried by a frame, which, by means of spurs and a vertical rack, has a vertical movement and enables the cores to be thrust up through the center of the bottom of the mold box and withdrawn when the molding is completed. As the core frame is lowered the mechanism which actuates it also actuates four vertical standards which carry the platen forming the bottom of the mold. These standards are elevated simultaneously with the lowering of the cores and serve to raise the molded block above the sides of the mold so that it can be easily removed.

The general operation of the mold having been explained, the reader will easily understand the detailed movements and mechanism, an explanation of which follows. The illustration shows the mold after molding has been completed, the mold opened, the cores withdrawn, and the block elevated for removal. Referring to the illustration, A are the end plates, and B the side plates of the mold. These plates slide on the bed plate, C, motion being actuated by the crank and shaft, D, which operate, by means of bevel gearing, the two end shafts and the opposite side shaft. One of the end shafts is shown at E, and the side shaft opposite the main shaft is shown at F. All four shafts carry pinions which mesh with racks on the side and end plates of the mold. The pinions and racks for one of the side plates are shown at G G. Each of the other plates has a similar pair of pinions and racks. As will be seen there are eight pinions and racks, two for each end plate and two for each side plate, and all of them are operated from a single shaft so that their movements are simultaneous. It will be understood, of course, that revolution of the main shaft in one direction opens the mold plates apart and that revolution in the contrary direction closes them together. The opening and closing travel is small, being about 1 in. for each plate, or just enough to free the block completely and allow it to be removed. When closed the mold plates are locked fast by suitable latches. To increase the size of the mold for larger blocks the end plates are unbolted and set further apart, and the side plates are removed and replaced by others of greater length and set further apart.

Turning now to the mechanism for handling the cores and raising the blocks, H shows the cores mounted on the frame, which is carried on the vertical rack, J. This rack is operated by a pinion on a jack shaft. When elevated the cores extend up through an opening in the bed plate, C, and project upward into the mold with their tops flush with its top edge. The platen, K, forms the bottom of the box and has openings which fit closely around the cores. This platen is mounted on the standards, L, the lower parts of which are provided with racks which engage with pinions on the shafts operated by the spur wheels, M and N. By turning the crank, O, the core frame is elevated, bringing the cores inside the mold and the platen is lowered to form the bottom of the mold. A reverse turn of the crank withdraws the cores from the mold and elevates the standards, L, the platen, K, which rests on them, and the block which rests on the platen.

In molding a block the sequence of operations is as follows: A revolution of the crank, A, raises the cores into position and lowers the platen to the bottom of the mold. The crank, D, is then turned, closing the sides of the mold, which are then locked. The concrete or cement and sand mixture is then tamped by hand into the mold and its top struck up flush with the top edges of the mold by means of a special trowel. A fractional turn is then given to the crank, A, to break the adhesion between the cores and the concrete. The sides of the mold are then thrown open by turning crank, D, and finally the cores are withdrawn and the block elevated by turning crank, A. The mechanism and block are then in the positions shown by the illustration.

To mold fractional blocks, thin metal transverse or longitudinal partitions are fixed in the mold by sliding them into suitable grooves in the cores and side or end plates. Different face designs are impressed on the block by fastening different cast pattern plates against one side plate of the mold. Blocks with curved or grooved ends, or with a face of different material or color from the body, are obtained by similar simple means.



ADJUSTABLE MOLD FOR MAKING CONCRETE BUILDING BLOCKS.
N. F. Palmer, Brooklyn, N. Y., Inventor.